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An appeal

With all humility we admit that some of the chapters in this publication are far from giving you a complete picture of the research works done in India. In future publications, we hope to rectify our lapses to the best of our ability. Such rectification is only possible with greater cooperation from the zoologists of our country. To make the future publications more meaningful and effective we earnestly appeal to zoologists of our country to kindly make available to the Society the sparable reprints of their publications which came out of the press during 1974. To the entomologists and to the physiologists working on invertebrates other than insects we specially request for reprints of such publications which came out during the period 1970-1973 besides those of 1974 so that we can try to fill in the lacunae of the present book.

Such reprints may kindly be sent to the Librarian, The Zoological Society, 35, Ballygunge Circular Road, Calcutta-19, during May, 1975.

Editors

Preface

The purpose of publishing this book is manifold. The most important ones among them are that this will serve as a directory of researchers in Zoology in India and an inventory for the types of research programme being carried out in different laboratories of India. Such an inventory has a tremendous value for intra and inter-disciplinary communicators within and outside India. Furthermore, such a directory shall also serve as a guideline for the sponsoring agencies in India and abroad. The Editors of the review are confident that this attempt will serve as baseline for future research programme in Zoology in India.

We admit that there are still many mistakes left in the book, both with respect to editing and printing, as well as in reference. We hope we will be able to improve this in our future attempt.

We are grateful to the National Council of Science and Technology for the financial support toward publication of this review. Thanks are also due to the authors of the reviews without whose active support, this publication would not have been possible. Finally, we acknowledge the untiring effort of The Eureka Printing Works (P) Ltd., for publication of the book.

The Editors

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STUDIES ON ANIMAL CHROMOSOMES AND GENE PHYSIOLOGY

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The investigations on animal chromosomes and genetics are carried out in various laboratories in India. The works done during 1970-1973 have been reviewed here. The various aspects of research undertaken in different laboratories can be broadly grouped under the following heads :

(1) Sex chromosomes and heterochromatin, (2) Chromosome evolution and cytotaxonomy, (3) Polytene chromosome, banding and puffing. (4) Induced chromosome aberrations, (5) DNA replication in *Drosophila* polytene chromosomes, (6) Dosage compensation in *Drosophila*, (7) Human chromosomes, (8) Chromosome banding, (9) Chromosome number, Sex chromosome constitution and meiotic behaviour, (10) Recombination and mutations in *Drosophila*, and (11) Developmental genetics.

Sex chromosomes and heterochromatin

Chandra (1970) has envisaged that the anomalies of the XO Turner syndrome are due to imbalance of sex-linked genes rather than developmental damage resulting from cell death. On the basis of his earlier observations in coccids he has suggested that in mammalian XO embryos the single X turns heterochromatic in some cells, but that such a change does not result in cell death because the X reverts back to an euchromatic and active state. The mammalian X inactivation might become reversed in response to special developmental needs. Chandra (1971) has tried to compare genetic systems involving developmental inactivation of chromosomes in coccids and mammals. He has shown several similarities as well as some contrasts between the two groups. According to him facultative heterochromatization which occurs in two widely different groups of organisms represents a fundamental capacity of chromosomes.

Ray-Chaudhuri, Singh and Sharma, T. (1970) have discovered that the somatic interphase nuclei of different tissues of females of various species of snakes, with a differentiated W chromosome, possess distinct chromocentre comparable to the characteristic mammalian sex chromatin. On the basis of absence of such a prominent body in males, the allocycly in the DNA replication of the W and the positive correlation between the size of the chromocentre and the size of the W in different species, they have concluded that the chromocentre in heterogametic female snakes is formed by the W chromosome. The lack of incorporation of ^{3}H-Uridine by the chromocentre indicates its inactivity. In order to distinguish this heteropycnotic body from the sex chromatin of the homogametic sex in mammals, they have termed it "W-chromatin". Ray-Chaudhuri, Singh and Sharma, T. (1971) have corroborated that there are various states of differentiation of Z and W chromosomes in snakes. They are homomorphic in primitive families like Boidae and in a few species of Colubridae, and well differentiated and heteromorphic in highly evolved families like Elapidae, Viperidae and Hydrophiidae. They have proposed that in snakes the differentiation of the W from the Z might have been initiated by the development of allocycly in DNA replication rather than by establishment of structural changes as the first step. On the basis of absence of co-existence of nucleolus and W-chromatin in the interphase nuclei of different tissues in a few species of snakes observed, they have presumed that the W-chromatin may be involved in the organisation of nucleolus in the snakes.

Multiple sex chromosome mechanism of $Z_1Z_1Z_2Z_2/Z_1Z_2W$ type in *Bungarus caeruleus* (Singh, Sharma, T. and Ray-Chaudhuri, 1970) and ZZ/ZW_1W_2 type in *Enhydrina schistosa*, *Hydrophis cyanocinctus*, *H. fasciatus fasciatus* and *Microscephalophis gracilis* (Singh, 1972 a and b) have been reported for the first time in vertebrates with female heterogamety. Ray-Chaudhuri and Singh (1972) have unequivocally demonstrated that the heterochromatic W in various species is allocyclic as far as its DNA replication is concerned. In *Bungarus caeruleus* and *Naja naja kaouthia* the W terminates its synthesis late while in *Boiga trigonata*, *B. forsteni*, *Naja naja naja* and *Vipera russelli russelli* it is not the last. In *Natrix piscator* the W chromosome finishes its replication alongwith other macrochromosomes, but during late S the W is hotter. Apparently there is no allocycly in the replicating pattern of the W_1 and W_2 chromosomes of *Hydrophis fasciatus fasciatus*, revealed by continuous labelling. However, asynchrony in the replicating pattern of the two W-chromatin bodies clearly indicates that there is definite allocycly.

Singh and Ray-Chaudhuri (1973) have reported localised, late replicating regions in various chromosomes of *Crocodylus palustris*. The interphase nuclei of various tissues have correspondingly shown a number of chromocentres. Thus in *C. palustris* unlike other reptiles, there is localised heterochromatin comparable to heterochromatin of mammals.

In a rodent *Bandicota bengalensis bengalensis* Sharma, T. and Raman (1971 a) have reported a normal female with XO constitution. The normal phenotype of the XO female (except for smaller ovaries) suggested the redundancy of one of the X's in this rodent also. On the basis of their observation and the reports published by others, on various rodents they have inferred, that one of the X chromosomes in the somatic cells of females is redundant and is perhaps dispensable for all the rodents without impairing fertility. In the same rodent *B. b. bengalensis* Pathak (1972 a) and Sharma, T. and Raman (1973) have also reported a sex chromosome polymorphism. The specimens trapped from different localities of India and Nepal have marked variation in the size and morphology of sex chromosomes. Simple acrocentric and composite subtelo- and submetacentric types of X chromosomes with their relative sizes of 5.9%, 7.5% and 9.6% of the genome, respectively, have been observed. The variation in the size of the sex chromosomes has been shown to be caused by deletion of constitutive heterochromatin. The Y chromosome has also been found variable, and usually a large X is combined with a large Y. A probable role of constitutive heterochromatin in speciation has been suggested on the basis of observation of preponderance of homozygotes for each type of X chromosome in populations.

In another rodent, *Nesokia indica* Jhanwar, Lakhotia and Rao (1971) have reported polymorphism of the Y chromosome. The heterochromatic Y varies in size and is acrocentric, subtelocentric or submetacentric. The composite metacentric X however, does not show polymorphism in this species.

Sharma, T. and Raman (1972 a) have discovered a unique multiple sex-chromosome system $X_1X_2Y/X_1X_1X_2$ in the tree mouse *Vandeleuria o. oleracea*. Because of the unusual sex-chromosome constitution, male as well as female have an odd diploid number (2n=29). The odd X_2 chromosome present in both sexes comprises 2.1% of the haploid complement. The relative length of the X_1 is 3.3%. The X_1 and X_2 together make the size of the conservative mammalian X chromosome (about 5% of the genome). This evidence suggests that the size of the mammalian X comprising about 5% of the genome is the level of threshold. The functional significance of this is not known.

The Indian house shrew *Suncus murinus* is characterised by the presence of a composite X and a large Y. The DNA replication study of the sex chromosomes has revealed controversial results. Rao, Sharma, V. K. and Shah (1970) have reported that the Y chromosome finishes its DNA synthesis earlier than the X and the autosomes in male bone-marrow and fetal cells. The X chromosomes in female cells behave differently in bone-marrow and fetal cells. One of the X's replicates early in fetal cells, but there is no definite pattern in bone-marrow cells. This observation does not conform to the hypothesis that only 5% of the haploid complement residing in the X chromosome is functional since it is presumed that early replicating region is genetically active. Therefore, they have proposed that the entire composite X and the large Y may be functional in this species. On the other hand, Sharma,T., Pathak and Ray-Chaudhuri (1970) have found in spleen culture and bone-marrow that the facultative heterochromatin is late replicating, and the constitutive heterochromatin of the composite X and the large Y are unequivocally the latest to terminate their synthesis. Rao, Rao, S.G.A., Sharma, V.K. and Shah (1972) have reported a late replicating Y in certain proportion of spermatogonial cells,but they have observed the X chromosome synthesising DNA synchronously with the autosomes in spermatogonia.

Garg and Sharma, T. (1972) have reported the presence of large blocks of constitutive heterochromatin in some autosomes of the flying squirrel *Hylopetes a. alboniger.* In this species a marked asynchrony in the DNA replication between euchromatic and heterochromatic regions is demonstrated. There are secondary constrictions and they are located at heterochromatic regions. On the basis of the presence of large blocks of constitutive heterochromatin a phylogenetic closeness of the Asian genus *Hylopetes* with the American flying squirrel *Glaucomys* has been suggested.

Sharma, V. K., Rao and Shah (1970) have studied DNA synthesis in sex chromosomes of the squirrel *Funambulus pennanti.* In females, in both *in vivo* and *in vitro* systems one of the X chromosomes has been observed to start DNA synthesis late and also terminate its synthesis later than the rest of the chromosomes. In males the Y has also been observed behaving similarly.

Dutta Gupta, Mitra and Mukherjee (1973) have presented evidence for the existence of β-heterochromatin and facultative type heterochromatin in the polytene X chromosome of *Drosophila ananassae.* It has been reported that there are two blocks in the X chromosome which at certain puff stage of the chromosome remain in compacted form when they fail to incorporate

rate ^{3}H-Uridine. It is suspected that decompaction and compaction cycle of the blocks might have certain influence on the puffing activity of the distal puffs of the chromosome.

Recently, Shah, Lakhotia and Rao (1973) have reviewed the properties of hetrochromatin in considerable detail.

Chromosome evolution and cytotaxonomy

Manna and Bhattacharya (1970, 1972), have worked out the process of karyotype divergence in the subfamily Gryllinae on the basis of their previous studies on several species and subspecies of this subfamily. The karyological data tend to suggest a reclassification of a few species. It has been proposed that heterochromatin may have had a role to play in the evolution of chromosome diversity of the group. Similar studies have been performed in the group Homoptera (Bhattacharya and Manna, 1970, 1973a, b ; Manna and Bhattacharya, 1973) and the evolutionary trend has been suggested.

Singh (1972 b) has carried out a comparative analysis of the karyotypes of all worked-out snakes and has mainly proposed the following : (i) The retention of Xenopeltidae as a separate family is unnecessary and the only species *Xenopeltis unicolor* referred to in that group should be included in the family Boidae. (ii) The cytologically known species of the problematic family Colubridae can be put into 13 different groupings which do not always correspond to the views of the present-day taxonomists. (iii) In Hydrophiidae, karyotype divergence seems to have occurred through changes in the fourth pair of autosomes and sex chromosomes in general and the W chromosome in particular. The structural rearrangement in this group have been brought about by fission and inversion.

Ray-Chaudhuri, R. (1973) has reviewed the karyotype evolution of birds by taking into account the total available data on karyology of birds. Because of the conservative nature of the macro-chromosomes they have been used as marker chromosomes. Using the macro-chromosomes as the parameter, she has proposed that 'fission' of metacentrics into acrocentrics has been one of the main mechanisms of karyotype evolution of birds.

The South Indian populations of *Rattus rattus* have been found to possess 38 chromosomes (Raman and Sharma, T. 1972 ; Satyaprakash and Aswathanarayana, 1972 a). The northern populations have 42 chromosomes (Ray-

Chaudhuri and Pathak, 1970; Sharma, T. and Raman, 1971 c). Lakhotia, Rao and Jhanwar (1973) have reported co-existence of *R. rattus* with 38 and 42 chromosome types in southwestern India. The karyotype of *R. rattus* with 38 chromosomes from India resembles exactly the karyotype of *R. rattus* with 38 chromosomes reported from elsewhere. The decrease in the number is caused by Robertsonian translocation. Raman and Sharma (1972) have proposed that the evolution of 38-chromosome type from 42-chromosome type must have occurred in India. Lakhotia *et. al.*, (1973) reported to have discovered two pericentric inversions also. They are of the opinion that the presence of 38-chromosome *R. rattus* in India is of an endemic origin.

Rattus cutchicus (Sharma, T. and Raman 1972 b) and *R. blanfordi* (Rao and Lakhotia, 1972) have 36 chromosomes, all of which are acrocentric. It is the most outstanding karyotype for a *Rattus*. Sharma, T. and Raman have proposed the removal of *R. blanfordi* from the subgenus *Rattus* and its placement in the subgenus *Cremnomys* to which *R. cutchicus* belongs.

Garg and Sharma, T (1971) and Sharma, T and Garg (1972) have reported the karyotypes of two different genera of squirrel.

Polytene chromosome, banding and puffing

Five or six groups of workers are engaged in India in the study of polytene chromosomes. However, the trends of these researches in polytene chromosome can be classified under two main heads. One, undertaken by several independent groups is mainly engaged in banding pattern and morphology of these chromosomes, the other, led by A. S. Mukherjee is engaged in genetic physiological studies on these chromosomes.

Chowdaiah, Avirachan and Seetharam (1970) have prepared a standard chromosome map of the mosquito, *Anopheles barbirostris*, which has close morphological similarity to other members of its group. Study of another species, *A. nigerrimus* and the preparation of standard map of salivary chromosomes have been done by Seetharam and Chowdaiah (1971).

Studies on rearrangements in polytene chromosomes of *Drosophila ananassae* have been conducted by Sajjan and Krishnamurthy (1970). Two new heterozygous reciprocal translocations have been reported by them, one involving the basal portion of the right arm of 2nd chromosome (2R) and right arm of X chromosome (XR), the other between terminal portion of 2R and 3R.

This is a unique case where one arm of the 2nd chromosome has participated in forming a translocation heterozygote with two different chromosomes, XR and 3R. The same authors (1972 a) have reported four more new gene arrangements in the same species. Of these 3 are heterozygous paracentric inversions (2Ld, 2Ra, 2Rb) and one translocation, (2L—3L) 10.

Sajjan and Krishnamurthy (1971) have examined the metaphase karyotype of *D. nasuta* larval neuroblasts. It consists of a pair of rods (X chromosome) in female, one of which is replaced by Y in male, a pair of V's (chromosome-2), a pair of double length rods (chromosome-3) and a pair of dots (chromosome-4). The structural variability in natural populations of *D. nasuta* has also been analysed (Sajjan and Krishnamurthy 1972 b). A total of 27 gene arrangements are reported : an overlapping inversion in the X chromosome, 6 inversions in 2nd chromosome and 19 inversions in 3rd chromosome. The same authors(1973) have prepared a detailed salivary gland chromosome map of a homozygous strain of *D. nasuta* showing 4 long arms and one short arm. They (1972 c) have also conducted population studies of *D. neonasuta* which have revealed one duplication, 3 inversions (2LA, 2RA, 3A) and one translocation, (2R-3) A. The paracentrics 2LA and 2RA exhibited nonrandom association.

Siddaveere-Gowda and Krishnamurty (1971) have analysed nine populations of *D. ananassae* from Western Ghats for the inverted gene arrangements. Of these only 6 populations are observed to carry the coextensive inversions (2LA, 3LA and 3Ra). A new inversion 2Rc has been observed in Sringeri population. Reddy and Krishnamurthy (1972 a, b) have studied populations of *D. ananassae* and have reported a simple paracentric inversion, XL13, an overlapping complex 2Le, an included type 2Lf and two heterozygous translocations, (XR—2L)8, (2L—3L)9 and a new pericentric inversion, (2L—2R)9.

Jha and Rahman (1972) have studied the role of chromosomal inversions in the evolution of the *D. bipectinata* species complex. *D. bipectinata* and *D. malerkotliana* differ from each other by three overlapping inversions in 2L, two included inversions in 3L and two overlapping inversions in 3R. These inversions are analysed on the basis of the salivary chromosome maps of *D. malerkotliana*. The reasons for the splitting up of the ancestral population which might have been heterozygous for common inversions, into four groups, each leading to the formation of a new species and the possible mechanism of the origin of sexual isolation between the groups have been discussed.

Rahman and Jha (1973) have also studied the inversion polymorphism in natural populations of *D. malerkotliana* from different localities in India. It is reported that these populations show qualitative and quantitative differences with respect to relative inversion frequencies.

After the reports by Ray-Chaudhuri and Jha (1964, not listed) and Sajjan and Krishnamurthy (1970, and previous report not listed,) a detailed and more conventional map of the polytene chromosomes of *Drosophila ananassae* has been made by Dutta Gupta, Mitra and Mukherjee (1973), using light and phase contrast microscope. Dutta Gupta *et. al* (1973) recorded a total number of 2687 bands in the 6 arms of *D. ananassae*, and divided them into 71 divisions.

The studies on puffing pattern in different species of *Drosophila* have been undertaken by Mukherjee and his coworkers. Dutta Gupta, Mitra and Mukherjee (1973 a) have presented important information on the relationship between phase change of facultative heterochromatin and puffiing pattern in the polytene X chromosome of *Drosophila ananassae*. A. Rai-Chaudhuri and Mukherjee (1970) have examined the locus-specific puffing pattern in a mutant *ft* in *Drosophila melanogaster*.

Mukherjee & Mitra (1973) have shown that Mitomycin C not only inhibits DNA synthesis by the polytene chromosomes of *Drosophila* but also induces considerable change in the ^{3}Thymidine labelling pattern. The drug induces considerable amount of exceptional labelling patterns which may be caused by repair synthesis. The Mitomycin induced altered patterns seem to be differential with respect to the X-chromosome of the two sexes (Dutta Gupta, Mitra and Majumdar 1973). The implications of these effects on the phenomenon of dosage compensation in *Drosophila* have to be examined.

Lakhotia & Mukherjee (1970a) have been able to induce a single specific puff by Benzamide at 93CD (3R) of *D. melanogaster* at the late third instar stage at the age of 84-90h. The induced puff is increased by about 5 to 6 times that in control and incorporates nearly 10x as much ^{3}H-Uridine as in control, despite that the same drug inhibits most of the chromosomal RNA synthesis.

Induced chromosome aberrations

Manna and his group have tested various chemicals viz., phenol compounds, antibiotics, insulin, maleic hydrazide, actinomycin D, base analogues, etc. for their mutagenic effect on bonemarrow chromosomes of the mice as well as on spermatocyte chromosomes of grasshopper. They have calculated the frequency of breakages at different time intervals after the chemical treatments. They have also done qualitative analysis of the aberrations in most of the cases. They have observed mainly chromatid type of breakages (Mitra and Manna, 1971 ; Manna and Mitra, 1971 ; Manna and Parida 1972 ; Manna and Das, 1972 ; Manna and Bhunya 1972 a, b). Manna (1973) has reported the possible induction of mutation by various types of bacteria and viruses, in mammalian systems.

Manna and Chakrabarti (1970) have reported chromosomal aberrations induced by the bacterium, *Staphylococcus* and its culture filtrate in the bone marrow cells of mice. The rate of aberration induced by the bacterium is reported to be higher than that by its culture filtrate.

Pre and post-treatments with ATP have reduced the frequency of aberrations induced by X-rays or actinomycin D (Manna and Mitra, 1971 ; Mitra and Manna, 1973).

Gururaj and Rajasekarasetty (1970) have studied the X-ray induced dicentric and side-arm bridges in the meiotic cells of grasshopper and have shown that the former has resulted by chromatid breaks and U-type union whereas the latter is by half-chromatid breaks followed by differential joining. The authors point out that the production of side—arm bridges renders evidence to the multistranded structure of chromosomes.

Rahiman and Rajasekarasetty (1971, 1973) exposed the male meiotic cells of *Poecilocera picta* to two types of treatments ; constant temperatures of 30°C and 40°C, and hormones 17β-estradiol and cortisone acetate. The former treatment induced desynapsis, univalent formation, cleavage suppression, despiralization etc. while hormone treatment caused stickiness, clumping, precocious hypocoiling, laggards, sticky bridges and ploidy. The two temperatures indicated differential qualitative responses, the effects of 30°C being well within the limits of tolerance and built-in homeostatic mechanisms of the experimental individuals. Regarding the two hormones, they evoked similar qualitative responses but varied in quantitative aspect.

Jayawant and Ranadive (1971) have carried out cytological studies on spontaneous and radiation-induced leukemia in mouse strain 'ICRC'. Besides an increase in the ploidy in the leukemic mice, no consistent structural abnormalities have been observed in experimental groups.

DNA replication in Drosophila polytene chromosomes

Lakhotia & Mukherjee (1970 b) have made an extensive observation on the DNA replication by the polytene chromosome of *Drosophila melanogaster* larvae by the use of ^{3}H-Thymidine autoradiography. They proposed that the continuous type labelling is at the initial phase of the S period and discontinuous type labelling subsequently follows until the terminal end of the S period. This has been further supported by the results of Mukherjee, Dutta Gupta, Lakhotia and Chatterjee (1970), Lakhotia (1970, 1971), Chatterjee and Mukherjee (1971 a, 1971 b, 1973) and Lakhotia & Mukherjee (1972 b). Mukherjee & Mitra (1973) substantiated this conjecture further by using Mitomycin C treatment preceding the ^{3}H-Thymidine labelling. They showed that Mitomycin C drastically inhibits the continuous patterns in both larval and prepupal salivary glands. Since Mitomycin C has been shown to inhibit the DNA synthesis by alkylating the DNA during the late GI-early S period, this observation by Mukherjee & Mitra (1973) has important bearing on the continuous labelling as the beginning of DNA replication.* Lakhotia & Mukherjee (1970 b) has further shown that the male X chromosome replicates faster than the rest of the genome as well as than the female X chromosome. This faster replicating property has been shown to be autonomous (Lakhotia 1970), and is probably regulated by a piecemeal mechanism (Chatterjee & Mukherjee 1971 a, b, 1973). The observed effect of Mitomycin C has been further supported by examining detailed labelling patterns in *D. melanogaster* by Dutta Gupta, Mitra & Majumdar (1973). Recently Mukherjee (1973) has reviewed the differential replication of DNA in *Drosophila* polytene chromosomes and has discussed the implications of such differential DNA replication on genetic regulation of eukaryotic genes.

Dosage compensation in Drosophila

Since the report that the male X chromosome in Drosophila synthesises twice as much RNA as each of the two X's of the female, (Mukherjee & Beermann, 1965 not listed), Mukherjee and his collaborators have shown that the male X-hyperactivity may be considered as the cytological counterpart of dosage compensation in *Drosophila* (Mukherjee, Dutta Gupta, Lakhotia & Chatterjee 1970, Chatterjee & Mukherjee 1971 c, Lakhotia &

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*Evidence to the existence of a third group of ^{3}H—thymidine pattern termed DD pattern has been obtained. This is possibly the initial pattern.

Mukherjee 1972b). Lakhotia & Mukherjee (1970b) further showed that the male X polytene chromosome of the larval salivary gland replicates its DNA much faster than the female X as well as than the rest of the genome, notwithstanding the fact that in general the male nuclei do show a faster replicating activity than the female nuclei. These conclusions are based on two most crucial observations, namely, low labelling frequency and high labelling intensity of the male X chromosome. That this property of the male X is a special property of stage, tissue or species specificity has been ruled out by subsequent works reported by Lakhotia (1972), and Lakhotia & Mukherjee (1972 b) in translocated X-autosome and in X irradiated chromosome of *D. melanogaster*, Chatterjee & Mukherjee (1973) in puffed and nonpuffed regions of *D. hydei*, Mukherjee & Mitra (1973) and Dutta Gupta, Mitra and Majumdar (1973) upon comparing the labelling patterns in larvae and prepupae and also in the different species (Lakhotia & Mukherjee 1971, 1972 a). Furthermore, Lakhotia (1970) working on ^{3}H-Thymidine incorporation in X-autosome translocation (or insertion) in *D. melanogaster* and Chatterjee & Mukherjee (1971 c, 1973) on their works on ^{3}H-Uridine lebelling and on ^{3}H-Thymidine labelling in puffs of the polytene chromosomes of *D. hydei* have shown that such faster replicating property as well as the hyperactivity of the male X are indications of piecemeal mechanism of genetic regulation of dosage compensation in *Drosophila*. Earlier works of Lakhotia and Mukherjee (1969, not listed here) have established cell autonomous nature of the male X hyperactivity.

It is needless to say that much more works must be done before a true picture of genetic regulation of dosage compensation is obtained. Lakhotia (1972) reported an evidence of differential response of dietary glutamic acid on the X-chromosomal width, transcription and replication between male and female. Similar differential response is presumably found also with X-irradiation (Lakhotia & Mukherjee 1972 b) and Mitomycin C (Mitra & Mukherjee 1972, Mukherjee & Mitra 1973).

Human chromosomes

Chandra, Reddy, Peter and Venkatachaliah (1971) have reported a Klinefelter with one extra partial X chromosome (2n=47, XX_q $-Y$). The partial X has been observed to synthesise its DNA always late. Kakati, Sharma, Udupa and Ray-Chaudhuri (1971) have reported a true hermaphrodite with XX/XY mosacism. The individual was phenotypically a male with ambiguous genitalia and bilateral ovotestis and gynaecomastia.

Dasgupta, Dasgupta and Balasubrahamanyan (1972, 1973) have investigated the chromosomes of several schizophrenic patients. A few cases have been found to have acentric chromosome fragments, XX/XY mosaicism or XXY chromosome constitution.

Chandra, Narayana, Buche and Hungerford (1972) by applying the "centroid" method of Barton, David and Merrington to a number of thymidine-labelled radioautographs have determined that in human the late-replicating X chromosome lies towards the periphery of the metaphase in a significant number of cases.

Chromosome banding

Sharma, T. and Garg (1973 a) have published the G-banding pattern of chromosomes of Indian muntjac, *Muntiacus muntjak.* The G-banding pattern resembles exactly the Q-banding pattern of the species reported by others. The same authors (1973 b) have also studied the C-banding patterns of two primates, *Presbytis e. entellus* and *Macaca mallatta.* In *P.e. entellus* the kinetochore regions of only 3 pairs of autosomes and the distal portion of the long arm of the Y have C-band whereas the kinetochore regions of all the chromosomes of *M. mulatta* have C-band.

Chromosome number, sex chromosome constitution and meiotic behaviour

Srikantappa and Rajasekarasetty (1970) and Srikantappa and Aswathanarayan (1970) have studied the chromosomes of two dermapteran species *Euborellia stali* ($2n=25/26$; $X_1X_2Y/X_1X_1X_2X_2$) and *Nala lividipes* ($2n=40$; XX/XY). The former is characterised by the presence of a multiple sexchromosome system and the latter by the largest diploid number among dermapterans.

Sharma, G. P., Mittal, Chaudhury, Pasahan and Sharma, O. P. (1970), Kaur (1970 a and b ;), have reported the somatic chromosomes of 19 species of house-flies ($2n=10$ to 12) and a few species of *Anopheles* and *Culex* ($2n=6$). The house-fly *Hemipyrellia pulchra* has X_1X_2Y multiple sex chromosomes. Parsad and Gandhi (1971) have reported that *Drosophila immigrans* and *D. nepalensis* both have 8 chromosomes.

The chromosomes of a large number of coleopteran species have been worked out (Manna and Lahiri, 1972 ; Dasgupta and Chakravarty, 1972 a, b and 1973; Dasgupta, 1973; Kacker, 1970, 1973). Dasgupta and his group (loc. cit.) have studied the chromosomes of 30 species of the families Carabidae, Chrysomelidae and, Tenebrionidae. Though different diploid numbers are found among different species of the first two families, the diploid number in all the 5 species of Tenebrionidae are constant (2n=20). Sharma, G. P., Handa, and Sharma, S. (1973) have, however, reported the diploid number ranging from 19-21 in 4 species of tenebrionid beetles. Kacker (1973) has reported 22 chromosomes in *Haplobrachium asperipensla.* Manna and Lahiri (1972) have listed the chromosomes of 46 species. Kacker (1970), in continuation of his previous work, has reported the chromosomes of 9 species of scarabid beetles. All the species, except *Adoretus versutus* which has 22 chromosomes, have 20 chromosomes. *Epilachna septima* (Coccinellidae) and *Caryedon gonagra* (Bruchidae) have 20 and 18 chromosomes respectively (Kacker, 1973). In general the sex chromosomes in males are of XY_p, XY or XO type.

Among Heteroptera 2 species *Catacanthus incarnatus* (2n=10) and *Chrysocoris purpureus* (2n=12) of family Pentatomidae (Dasgupta, 1971) have been studied. The males of *Cimex hemipterus* have X_1X_2Y sex-chromosome system.

Chatterjee and Manna (1971) have studied the chromososomes of 3 tettigonid grasshoppers. They are endowed with a big X chromosome which is the largest in the complement.

Chromosomes of several other invertebrates have also been studied. *Macrobrachium silvakensis, Paratelphusa mesomiana* and *Potamon koolooense* (Crustacea-Decapoda) are characterised by a high diploid number 100, 134 and 180, respectively (Mittal and Dhall, 1971). Mittal (1970 a and b) has studied the chromosomes of 5 species of spiders.

Vasudevan, Rao and Rao, S. R. V. (1973) have described somatic and meiotic chromosomes of *Heteropneustes fossilis.* The sex chromosomes of this species are not identifiable.

Singh, Sharma, T. and Ray-Chaudhuri (1970) have worked out the chromosomes of 5 species of Amphibia viz. *Rana t. tigrina* (2n=26), *R. t. crassa* (2n=26), *Rhacophorus maculatus* (2n=26), *Bufo andersoni* (2n=22) and *B. melanostictus* (2n=22). The sex chromosomes are not identified in any of the species. Mittal and Sawhney (1971) have also found

22 chromosomes in *B. melanostictus*. They have reported $2n=26$ in *Rana cynophylectis*.

The chromosome number and sex chromosome constitution of 23 species of reptiles, mostly snakes, have been reported by Singh, Sharma, T. and Ray-Chaudhuri (1970). Singh (1972c) has also carried out the karyotype analysis of 3 species of turtles. Both the sexes are chromosomally alike and therefore the sex chromosomes are unidentifiable. Dutt (1970) has reported variation in chromosome number ($2n=36$ and 38) in two populations of *Xenochrophis piscator* (Colubridae).

Srivastava and Misra (1971) have studied the somatic chromosomes of *Streptopelia decaocto* (Aves—Columbiformes). They have identified the W chromosome in females of this species.

An interesting finding of a reduced diploid number ($2n=32$) in the Mysore population of the Indian house shrew, *Suncus murinus* has been reported by Satyaprakash and Aswathanarayana (1972b). The reduction in the diploid number is associated with an increase in the number of metacentrics. Obviously, Robertsonian translocation has been the cause of this numerical reduction.

In sixties there had been some controversy about the diploid number and the identification of sex chromosomes of the five-striped squirrel *Funambulus pennanti.* The recent study of the Varanasi population by Garg and Sharma, T. (1971) agrees with the earlier findings of Rao, S. R. V. and his associates. The diploid number is 54 and the X is a large submetacentric and the Y is a small acrocentric. Rao, Lakhotia and Jhanwar (1972) have studied the chromosomes of *Funambulus tristriatus.* They have reported 46 chromosomes in it, but its karyotype differs from that of *F. p. palamarum* ($2n=46$) studied by Satyaprakash and Aswathanarayana (1971a, 1973). Rao *et. al* (1972) have discussed the probable mode of origin of different karyotypes of the genus.

Satyaprakash and Aswathanarayana (1971 b) have reported 40 chromosomes in *Rattus (Millardia) gleadowi*, but in *Rattus* (*Millardia*) *meltada* the diploid number is 50 (Sharma, T. and Raman, 1971 b ; Satyaprakash and Aswathanarayana 1972 c). Pathak (1971 a) and Satyaprakash and Aswathanarayana (1972 d) have reported occurrence of supernumerary chromosomes in *Rattus rattus*. Raman and Sharma, T. (1971) have reported a composite X and a large Y in the low crested porcupine *Hystrix indica.* The Y and the pericentric region of the X are late replicating. Ray-Chaudhuri, Pathak and Sharma, T. (1971) and Pathak (1972 b) have described the karyotypes of one species of megachiropteran and 5 species of microchiropteran bats. Sharma, T. (1972) has substantiated the presence of only 7 chromosomes in males of the Indian muntjac *Muntiscus muntjak*, and had confirmed the presence of XY_1Y_2 multiple sex-chromosome system in males by studying meiosis.

Chromosome number and/or karyotype of a number of species of mammals from India have been reported. Investigations on many of the species have been reported by various workers (Avirachan, Mehta and Sugandhi, 1971 ; Pathak, 1971 a and b : Ray-Chaudhuri and Pathak, 1970 ; Satyaprakash and Aswathanarayana 1972 e-h ; Sharma, G. P., Mittal and Sandhu, 1971 ; Sharma, G. P., Mittal and Kaul, 1971 ; Sharma, A. P., Mittal and Sobti 1971 ; Sharma T. and Raman, 1971 c ; Bhatnagar and Srivastava, 1972 ; Srivastava and Bhatnagar, 1973).

Recombination and mutations in Drosophila

Extensive studies have been made on crossing over in *Drosophila* with special emphasis on male crossing over in *D. ananassae* by Kale in Banaras Hindu University. On the basis of the results on assay of daily broods, Kale (1971) has shown that X-ray induced recombination in male is much higher in pupae than in larvae and adults. Kale's results are consistent with the occurrence of cambial-like divisions of the predefinitive spermatogonial cells of *Drosophila*.

In an attempt to re-examine the phenomenon of male crossing over in *Drosophila ananassae*, Mukherjee and Das (1970, 1971) discovered an association between the male crossing over in the third chromosome of *D. ananassae* and segregation distortion. Mukherjee and Das (1971) showed that under normal condition the segregation distortion observed in *D. ananassae* was always found among the recombinant progeny. The involvement of penetrance, expressivity, viability, preadult development time etc., has been ruled out by detailed developmental analysis of *px* and *pc* mutants with which this phenomenon is associated (Das, 1972).

Recently, in a very extensive study, Jacob and Ray-Chaudhuri (197[illegible]) showed the role of reduced glutathione and 2-aminoethyl isothiouranium Br, HBr (AET) as radioprotective agents,

Developmental Genetics

Datta & Mukherjee (1971 a) examined the possibility for the existence of prepattern affecting mutant genes in *Drosophila melanogaster.* They showed that a mutant combgap (*cg*) causes certain precise changes in the sexcomb and basitarsal bristle pattern of *D. melanogaster* which suggest that the mutant may be of prepattern type. In combination with such mutants as engralled (*en*), sexcombless (*sx*) and transformer (*tra*), combgap was always seen to interfere with the process of sexcomb formation at a stage when the sexcomb prepattern was determined during development. It also alters the cell movement preceding the arrangement of the sexcomb on the basitarsus. Datta and Mukherjee (1971 b) also examined the sexcomb pattern formation in intersexual forms of *Drosophila bipectinata* and *D. melanogaster*. Mukherjee & Ganguly (1970) have shown that inversion in heterologous chromosomes affects the somatic crossing over in *D. melanogaster*. In another set of investigation on genetic interaction between *sx*, *tra* and *dsx*, Mukherjee and Hildreth (1971) proposed a time-wise sequence of action of these genes in sex determination in *Drosophila melanogaster*.

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HISTOCHEMISTRY

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The abundance of current histochemical literature in quite diverse fields, necessitated (and restricted) a concise review of only the more significant contributions in the field. It has been found more feasible to group together the work of several workers in related fields. Following is the broad outline of the pattern of the present coverage (1970-73) :

1. Cytochemistry
2. Histoenzymology and Polysaccharide Histochemistry
3. Neurohistochemistry
4. Myohistochemistry
5. Gonadial Histochemistry
6. Experimental Histochemistry
7. Invertebrate Histochemistry

An analytical description of the work undertaken in each of the above mentioned groups is followed by an exhaustive bibliography of the references cited.

Cytochemistry

Dutt (1-14) conducted extensive cytochemical studies on the Schiff and pseudo-Schiff type reactions of the nucleic acids in numerous tissue, using a variety of dyes. He concluded that in both Schiff and pseudo-Schiff type reactions the dyebinding sites of the acid-hydrolysed DNA are many. The reactivity of the dye and DNA is optimum only at a particular pH of the leuco dyes. All the dyes containing primary amino group react with acid-hydrolysed DNA. But, the Schiff type of reaction is also possible with dyes having molecules without any primary amino group. The molecules of these dyes do, however, contain tertiary amino group. In alkali-hydrolysed material the staining of the nuclei produced is due to the phosphate group of DNA, while in the acid-hydrolysed ones it is due to the aldehyde molecules of DNA. Dutt could successfully achieve specific binding of Celestian Blue B-Iron complex with the phosphate groups of the nucleic acids. His studies dealing with the determination of DNA content by Feulgen-Microspectpophotometry revealed the occurrence of aneuploidy and various degrees of polyploidy in the mammalian liver.

Kasturibai and co-workers (15-16) studied the cytochemical aspects of certain ciliates, particularly during division. They suggested that at the time the mitotic trigger is released in *Blepharisma intermedium* at 38°C, requisite quantities of carbohydrates, proteins, lipids, thiol groups, enzymes—phosphatases, succinic dehydrogenase and urease are present, and hence fission rate is maximum. They studied the cytochemical localization of some macromolecules like proteins, lipids, carbohydrates and of a few oxidative and hydrolytic enzymes at different stages in the life cycle of two hypotrichous ciliates. Their investigations indicated that there is a periodic decrease and increase in the cell constituents as well as in their localization, during the different stages of cell cycle. Parallel studies were made by Shadaksharaswamy and Jyothy (17) on the cytochemical changes in *B. intermedium* at pH values most favourable for fission in different buffers. There were variations in concentration of lipids, carbohydrates and proteins, and enzymes—succinic dehydrogenase, acid and alkaline phosphatases, with changes in buffer, pH and molarity. The works of these authors (15-17) present significant exposition of the cytochemical aspect of fission in ciliates.

Histoenzymology and Polysaccharide Histochemistry

Varute and associates (18-57) made an extensive study of the histoenzymology of certain lysosomal enzymes, the histochemical identification of muco-substances, and the basic aspects of the histochemistry of polysaccharides and also of the galactogen metachromasia, in the various tissue-organs of vertebrates and invertebrates. Varute investigated the histoenzymology of B-glucuronidase in the various organs of metamorphosing and adult amphibians during seasonal breeding-hibernation cycles and noted concomitant changes in enzyme activity and sex hormone level, thereby suggesting the use of histochemistry in the study of hormone-enzyme relationships. He also evaluated, and improved upon, the basic histochemical technique for the demonstration of B-glucuronidase activity and suggested a possible isoenzymic existence of the enzyme in the cytoplasmic and lysosomal fractions of the tissues investigated. The physiological role of the enzyme activity during the breeding hybernation cycle was also emphasized. Vartue put forth the possibility of the importance of lysosomes in the secretion of endocrine glands, after observing the simultaneous and similar variations in the secretory and B-glucuronidase activity of the Leydig cells of frog testis. Parallel studies were attempted by Vartue *et al.* on the histochemical identification of mucosubstances and their possible physiologic significance in the various tissues of different animals. Such studies include the study of mucosubstances in the epidermis of *Pheretima elongata*, thyriod of a bat, gall bladder of a cat, oesophagus of lacertilian reptiles, tongues of adult and tadpole amphibians, mucous glands of bats lingual mast cells and muscle fibres of a variety of vertebrates. They broadly concluded that all the non-mammalian vertebrate tongue muscles contained glycogen and lacked any acidic mucosubstances. The components of the mucosubstances-containing lingual muscle fibres were identified as a mixture of sulphomucins and hyaluronic acid. On the basis of identical sites of activity of alkaline phosphatase and sialomucins (in the brush border of molluscan intestine) Varute and Patil (57) suggested the sialoglycoprotein nature of alkaline phosphatase. Varute and Nanaware (50) studied the galactogen metachromasia in general and its solvent and thermal lability.

Talesara *et al.* (58) devised a substantially modified sequential staining technique for the correct histochemical localization of lactic dehydrogenase activity in the fibres of mixed skeletal muscle. They could readily demonstrate that, as supported by biochemical findings, even the histochemical profile for the enzyme activity reveals relatively higher level of lactate oxidation in the white than in the red muscle fibres.

Neurohistochemistry

Singh and Mukherjee (59), studying the histochemistry of neuronal and extraneuronal lipofuscins in the avian and mammalian brain, suggested that the extracellular distribution of lipofuscin granules appeared to be consistent with the possibility of some *in vivo* lipofuscin removal (elimination) from the brain tissues, and that lipofuscin pigment (formed from altered lysosomes) is devoid of any active metabolic and physiologic activity. Investigating the sugested possibility of a histochemical demonstration of the chemical structure of individual lipofuscin granules, Singh (60) concluded that they did not possess a concentric layered chemical built-up in them.

Studying the histochemistry of the saccus vasculosus of some fresh water teleosts Narasimhan and Sundararaj (61) demonstrated that the coronet cells had conspicuous presence of the activity of phosphorylase and glucose-6-phosphatase. Besides these, lactic dehydrogenase, NADP diaphorase, NAD diaphorase and succinic dehydrogenase were also localized in the coronet cells. They suggested that the coronet cells contained glycogen as a polysaccharide.

Tewari *et al.* (62-73) attempted some revealing work on the histochemical aspects of the central and peripheral nervous system and certain sense-receptor organs of various vertebrate groups. Their studies include mostly qualitative mapping of the activity loci of certain phosphatases, esterases, and 5-nucleotidase in the different regions of the brain of several vertebrates, and also in the spinal and cranial neuronal bodies. They made parallel studies to investigate the physiologic implications of the pattern of histochemical localization of the activity of these enzymes at certain reptilian and piscine sensereceptor sites.

Myohistochemistry

Demonstrating histochemically, Talesara (74) suggested the possible involvement of succinic dehydrogenase activity in providing energy to the cnidoblast cells of hydra for discharging their nematocysts. He also made an attempt to characterize histochemically the three types of fibres in an Indian snake. Talesara and co-workers (74-79), engaged in investigating histochemically the enzymes and metabolites of muscle energy metabolism, improved upon the existing technique for the demonstration of lactic dehydrogenase activity in mixed skeletal muscles. During this study they worked out certain aspects of enzyme (LDH) leakage from the various component fibres of fixed and unfixed mixed muscle sections, and successfully demonstrated that their technique specifically shows higher LDH activity in white muscle fibres. Talesara and Kumar (77-78) initiated a series of histochemical (physiological) investigations on the fibre-architecture and energy metabolism of certain mechanically specialized muscles of sub-human primates. Studying the *in vivo* ontogenesis of exclusively red skeletal muscle (the *pectoralis major* muscle of certain microchiropteran bats and weaver finches) Talesara and Kumar (79) substantiated the relative independence of neural (nevro-trophic) control of the red muscle in general.

Gonadial Histochemistry

Studying the activities of various enzymes in spermatozoa, and during spermatogenesis in general, Mathur and Singh (80-81) suggested that ATPase could be the key enzyme in the regulation of the spermatogenetic phenomenon and no significant differences occur in the enzymic constitution of the spermatozoa of the different inbred strains of mice.

Nayyar and Sundararaj (82) attempted a histochemical investigation of certain piscine accessory sex organs. While studying the histochemistry of the seminal vesicles of the catfish (*Heteropneustes fossilis*) they demonstrated that its secretion contained mucoproteins, acid mucopolysaccharides, primary proteases, besides traces of phospholipids and native proteins.

Guraya and his associates (83-110) made an extensive effort, as reflected by numerous interesting publications of wide variety, to elaborate the morpho-physiological facets of the various components of ovary and testis of primates, lower mammals, submammalian vertebrates, lower vertebrates and several invertebrates, by histochemical techniques. Several outstanding achievements have been made in revealing the comparative aspects of follicular growth and atresia ; interstitial gland tissue ; ovulation ; corpus luteum formation, regression and function ; spermatogenesis and spermatozoa. Finer studies were carried out to study the mitochondrial alterations (both cytochemical and ultrastructural) during spermatogenesis of opossum and ram, concluding that the stored intramitochondrial lipids might be the chief source of oxidative energy during the passage of spermatozoa through the. epididymis. The contributions of the acrosomal vesicle and granule (formed by the activity of the golgi complex) to the formation of the acrosomal cap of vertebrate spermatozoa were also explored histochemically.

Experimental Histochemistry

Rana and co-workers (111—115) studied extensively the histochemistry of various tissues of vertebrates under certain experimental conditions. Their investigations were largely comparative, and besides investigating the histochemical effects of toxin administration, they also studied the distribution pattern of some heavy metals in many tissues of squirrel. They made an attempt to relate the toxin-induced histochemical change in certain tissues with the general problem of carcinogenesis, since the observed changes were considered to be of usual occurrence in tissues treated with spceific carcinogens. In their experiments dealing with histochemical effects of sex-hormone treatment and castration on squirrel kidney, they elaborated the degree of enzyme inhibition or activation in the light of the problem of hormonal carcinogenesis. Rana any Tyagi (115) established a correlation between the enzyme activity in the heart muscles of crab and the rate of adrenaline induced stimulation.

Shah *et al.* (116—122) extensively applied histochemical techniques to evaluate the role of certain enzymes and energy-metabolites in the morpho-

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physiological events accompanying the tail regeneration in lizards, and hepatic wound-healing in the pigeons. They related the fluctuations in the ascorbic acid level during different phases of tail regeneration with various states of metabolic activities of the corresponding phase. Shah and Chakko (177) evaluated histochemically the participation of nervous influence in the stimulation or initiation of tail regeneration process in the house lizard, and noted a negative result to that effect (insofar as the possibility of the neurotrophic influence of acetylcholine and other cholinesters is concerned). They further suggested that the high concentration of RNA in regenerating tail is related to the active protein synthesis during the differentiation and growth of various tissues. Working on similar aspects, Asnani *et al.* (118) suggested that as wound-healing proceeded, the machinery for aerobic metabolism became less active while the dividing cells became more and more dependent on anaerobic metabolism. In respect of the activity of aldolase during lizard tail regeneration, Shah and Ramchandran (119) noted that with the completion of differentiation and commencement of growth phase the enzyme activity gradually decreased (after an initial increase during the differentiation phase) in the fully regenerated tails to a level that of normal tails. The involvement of phosphomono-esterases I and II in hepatic wound-healing in pigeons could be confirmed by Pilo *et al.* (121) who found a preferentially early increase in acid phosphatase activity during the initial degenerative (phagocytic) phase, while alkaline phosphatase activity increased during tissue repair phase (synthetic). Shah and Ramchandran (122) suggested that malic enzyme activity during blastema and early differentiation phase in regenerating tails of lizard could aid in lipid biosynthesis by supplying $NADH_2$.

Ghosh and his associates (123—129) made histochemical investigations on the adrenal medulla, pancreas, neuroendocrine system and uropygial gland of some vertebrates under various experimental manipulations.

Invertebrate Histochemistry

Gupta and Sharma (130—134) made some histoenzymorphological studies on the distribution pattern of certain phosphatases in selected organs of some trematode parasites. They also extended their investigations to explore the histochemical aspects of spermatogenesis, and of the effect of drugs *in vitro* on some of these parasites.

Dev and Mishra (135—138) conducted certain enzyme-histochemical investigations concerning the physiologic significance of the distribution patterns of certain phosphatases in the body wall, receptor organs, the 'biting-sucking' complex, and the ventral nerve cord of the Indian medicinal leech.

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CELLULAR AND COMPARATIVE PHYSIOLOGY

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The physiological researches conducted in the different Zoological laboratories in India during the last three years may be reported under two sections, I. Cellular and molecular physiology and II. Comparative and adaptational physiology. The investigations in the fields of Endocrinology and Insect Physiology have been reviewed separately elsewhere.

Cellular and Molecular Physiology

The fundamental activities of all forms of organism—microbes, plants and animals—at the levels of cellular and moleceular organization are essentially identical, despite the difference in minor details. A number of Zoologists of our country, within the last three years, have employed various experimental methods to explore the basic cellular and molecular mechanisms of animal functions.

1. Enzymology : The relationship between enzymatic activity patterns and the charge densities inside a cell (electrical characteristics of the cellular "microenviroment") has been investigated in tissues like frog skeletal muscle and mammalian liver, kidney and brain by Prof. Swami and his associates at S. V. University, Tirupati. When a tissue is exposed to a voltage gradient, the cytosol fraction of the sarcoplasm undergoes subcellular electromigration resulting in a polarization of the cells into anodal and cathodal segments (Bojjireddy and Swami, 1971a ; Muralikrishnadass and Swami, 1971a & b). This sort of electrical polarization (grouping of charged molecules like proteins, amino acids, etc.) in the cell produces a metabolic polarization, as evidenced by significant difference between cathodal and anodal segments in various enzymatic activities like phosphatases, glutamate—pyruvate transaminase, cholinesterase, aldolase, succinic dehydrogenase. protease, asparate and alanine aminotransferases etc. (Subbaramireddy and Swami, 1970a and b ; Swami and Bojjireddy, 1970 : Bojjireddy and Swami, 1971a ; Muralikrishnadass, 1972 ; Sreelakshmi and Swami, 1972), and even in the capacity of incorporation of ^{14}C-leucine into protens (Subbaramireddy and Swami, 1971).

Kinetic properties and regulation of activities by different factors of various enzymes in mammalian tissues have been studied chiefly in the laboratories of Prof. Swami and Prof. Kanungo (B.H.U., Varanasi). The activity of brain obviously depends on different neurotransmitters (NT). Kaur and Kanungo (1970a) have shown that the brain cholinesterase of rat is inhibited by NT like 5-hydroxytryptamine (5HT), epiniphrine (Ep) and norepinephrine (nor-Ep), whereas gamma-amino-butyric acid (GABA) stimulates the activity of this enzyme. On the other hand glutamic dehydrogenase of brain and liver in rat is inhibited by 5-HT, acetylcholine (ACh) and nor-Ep, while Ep stimulates it (Kaur and Kanungo, 1970b and c). Kesavarao *et al.* (1970) have studied the effects of histamine and some anti-histaminic agents (like pheniramine maleate) on the activity of proteases in sheep liver. Histamine and anti-histamines separately induce similar enzymatic disturbances, while both together seem to restore the normal activity of the enzyme. Kesavarao *et al.* (1972) have also investigated the inhibition patterns of sheep liver arginase activity by some l-amino acids. Ornithine, lysine, leucine, isoleucine, valine and proline inhibit the activity of this enzyme significantly, while other amino acids produce variable effects. Besides, leucine and isoleucine compete with each other with regard to the inhibition of the enzyme activity. The negative cooperative effect of leucine is reversed by certain divalent cations (Mn^{++}): Acetylcholinesterase, important for synaptic transmission (in cholinergic synapses), is inducible in the brain by 17-beta-estradiol in immature and adult female rats (Moudgil and Kanungo, 1973a and b). Singh (1973) has demonstrated an inhibition of both the cytoplasmic and mitochondrial isozymes of malic dehydrogenase (cMDH and mMLH) in brain and heart of rat by citrate, although the mMDH is found to be more sensitive to this inhibtor.

A circadian rhythm of acetylcholinesterase activity in the brain of rat (a peak at 6.00 A.M. and a trough at midnight in immature rats ; the reverse in the adults) has been reported by Moudgil and Kanungo (1973c).

2. **Macromolecular biosynthesis**: The investigations of Kanungo *et al.* (1970), using ^{14}C-uracil and ^{14}C-leucine, have proved that the different organs of rats have different rates of protein and RNA turnover, and this again is a function of the age. The protein synthetic rate, in terms of the labelled amino acid uptake into total proteins, is found to be higher in the anodal segment of frog gastrocnemius or sartorius muscle than in the cathodal part (polarities created by subjecting the muscle to a field of voltage gradient), as reported by Subbaramireddy and Swami (1971). Shah (1970,

1971 and 1972) has been able to demonstrate *in vivo* and *in vitro* synthesis of DNA and RNA in the chloroplast of *Euglena*, indicating an autonomy of this organelle so far as its reproduction is concerned.

3. **Metabolism and Vitamin** C : Chinoy (1970a & b, 1971a & b, 1972a & b) has made a comprehensive investigation of the ascorbic acid metabolism, its utilization by different tissues, its free radical formation and resulting complex with macromolecules. Patnaik (1971) has described a significant decrease in the level of ascorbic acid content of liver and testes of albino rat following cadmium chloride treatment. The depletion in testes is considered to be secondary to ischaemia and that in liver due to inhibition of the enzymatic systems controlling ascorbic acid biosynthesis.

4. **Immunochemistry** : Relatively little work has been done in the fields of immunology and immunochemistry in our zoophysiological laboratories. However, Kanungo (1971) has proposed a model for the origin of heavy (H) and light (L) chains of antibody molecules through analysis of available biochemical and genetical data. L chain has a variable (*v*) and a constant (*c*) part, which are equal in length. H chain has a *v* segment that is equal in length to *v* of L chain, and a *c* segment that is three times longer than its *v*. According to Kanungo's model, two primordial genes, *v* and *c* formed a "vc_8" gene by translocation and this coded for the L chain. Also, the *c* gene duplicated to give "c_2c_3" gene. Then translocation of "vc_8" to "c_2c_3" gave "$vc_8\ c_2c_3$" gene, which coded for H chain.

5. **Cytodifferentiation and morphogenesis** : A perusal of the available reports indicates a paucity of biochemical investigations in our country on the genetic control of cellular differentiation and morphogenesis. However, the cellular bioenergetics of regeneration in *Hydra vulgaris* has been investigated in the laboratory of Dr. Datta of Kalyani University, Kalyani, West Bengal. Assuming that regeneration of the decapitated hypostome is achieved from the reserve energy pool like ATP and macromolecules like m-RNA, effects of actinomycin-D (AD), ATP, ATPase and RNAase were tested on the initial process of regeneration. The regeneration could be stopped completely by AD if the animals were treated for 48 hours or more with this drug before amputation. Treatment for less than 48 hours did not completely inhibit regeneration (Datta and Chakravarty, 1970). Neither ATP could accelarate the rate of regeneration, nor ATPase treatment prior to amputation could completely inhibit the process. But treatment with ATPase followed

by treatment with inhibitors of oxidative phosphorylation (like DNP) could inhibit the regeneration completely. RNAase, however, could only delay the process without completely inhibiting it (Datta and Mitra, 1972). These results suggest that the initial phase of regeneration is most likely independent of the dynamic metabolic events like oxidative phosphorylation and synthesis of macromolecules (m-RNA). The restitution process initiates from the preexisting necessary raw materials and continuation of this process requires new synthesis through normal metabolic activities.

6. **Muscle physiology :** When a skeletal muscle of a vertebrate is denervated, it undergoes progressive atrophy and this is associated with changes in many physiological and biochemical properties of the muscle. The subcellular electro-migratory pattern and the activities of different enzymes of the denervated frog leg muscles have been studied in Prof. Swami's laboratory at S. V. University, Tirupati by Muralikrishnadass and Swami (1971a & b). An increase in gamma-globulin type of protein and a simultaneous increase in the activity of glycolytic enzyme like aldolase have been detected during denervation atrophy (Bojjireddy and Swami, 1971b). Das and Srivastava (1972) have investigated the nature of the kinetics of denervation atrophy in four leg muscles of rat. Like the kinetics of many complex biological phenomena (such as the rate of bacterial growth after the lag phase), the kinetics of decrease in wet and dry weights of denervated rat leg muscles has been characterised as the first order type, and this has been analysed at the levels of the diminutions in total protein content, protein/DNA ratio and different protein fractions (collagenous, sarcoplasmic, actin and myosin proteins). The precise knowledge of the course of atrophy in the different biochemical parameters of a neurotomized muscle (or a dystrophic muscle) can enable a clinician to give a proper therapeutic help at the right time to the degenerating muscle for prevention or retardation of atrophy. A "short term effect" of denervation (within 24-30 days) has been described by Krishnamoorthy and Das (1973) in frog gastrocnemius muscle, as distinguished from the effects of "chronic denervation" (after 30-40 days). During this "short term" period of deprivation of motor innervation, hypertrophic (rather than atrophic) changes in certain biochemical parameters (water content, total protein concentration or protein/DNA ratio, maximal net synthesis of protein and turnover of collagenous protein) occur in frog gastrocnemius muscle.

7. **Radiation physiology :** Remarkable alterations of enzymatic activities (phosphatases and dehydrogenases), concentrations of protein, nucleic acids,

histamine and other metabolites in different tissues of laboratory mammals, exposed to different dosage levels of X-irradiation, have been reported by Bhatavadekar *et al.* (1972) and Shah *et al.* (1972). However, no work has been done on the cellular effects of other ionizing radiations and U. V. radiation.

8. **Biochemical Gerontology** : A group of researchers in the biochemistry laboratory of Prof. Kanungo has explored the molecular mechanisms of aging in rats in some details. A review of the publications on the biochemical alterations produced by senescence and the various theories of aging has been prepared by Kanungo (1970). The "gene regulation" theory of aging, proposed by Kanungo (1970) explains the phenomenon of senescence as a consequence of alterations in the template activities of genes, induced by accumulations of certain substances necessary for growth and maturity. Obviously aging is a spontaneous process and is a continuation of differentiation and morphogenesis which occur according to a set programme by sequential activation and repression of genes. This theory aims at answering two important questions pertaining to the problem of aging : (1) What triggers the aging process ? and (2) What determines the life span of a particular species ? This theory is based on the different findings on the alterations of the rates of macromolecular biosynthesis, of the isozyme patterns of different enzymes, and of the inducibility of various enzymes (by the respective effectors) as functions of age in rat. Kanungo, Koul and Reddy (1970) have studied concomitant synthesis of RNA and protein in various organs of young and old rats using ^{14}C-uracil and ^{14}C-leucine respectively and have found that these activities change at different rates for each organ with increasing age. The testis has the highest rate of RNA synthesis in the young and the lowest in the old as compared to other organs. Also, its rate of protein synthesis is considerably reduced in old age. The regulatory effects of different biogenic amines (acting as neurotransmitters), such as 5-HT, EP, nor-EP and GABA, on the brain enzymatic activities (cholinesterase and glutamate dehydrogenase) of rat become diminished in older rats and such changes may be responsible for the decreased brain activity in old age (Kaur and Kanungo, 1970a, b & c). The activity of the cytoplasmic isozyme of malic dehydrogenase (cMDH) in the liver of young as well as old rats decreases after adrenalectomy (A) and increases after administration of cortisone to adrenalectomized rats. These changes, however, are less marked in old rats (Kanungo and Gandhi, 1972). The A decreases, and administration of cortisone to adrenalectomized rats increases the activity of mitochondrial isozyme of MDH (m MDH) of young

rats only, and not of old rats (Kanungo and Gandhi, 1972). After hepatectomy, however, mMDH can be induced by cortisone in the regernating liver of old rats also. Immunolgical studies on the purified MDH of young and old rats show that the molecular species of the enzyme is apparently the same at both the ages. So the changes in the levels of the enzymes and their inducibility seen in old age may be due to alteration in the template activity of the corresponding genes. Such repairs of impairment of induction has been accomplished for glutamine synthetase (Rao and Kanungo, 1972) and arginase (Kanungo *et. al.*, 1972) in rat liver. Patnaik and Kanungo (1973) have shown that, whereas cytoplasmic alanine aminotransferase (cAAT) is induced by hydrocortisone in the liver of rat throughout its life span, mitochondiral AAT (m AAT) is induced only in the old and not in the young animals. Acetylcholinesterase of brain is induced by 17-beta-estradiol in the immature and adult female rats, but not in the old animals (Moudgil and Kanungo, 1973a and b). Besides, the circadian rhythm in the activity of this enzyme shows a shift in the phase in adult rats (peak at midnight and trough in the morning) as compared to the immature ones (peak in the morning and trough at midnight), as reported by Moudgil and Kanungo (1973c).

The common garden lizard, *Calotes versicolor*, has also been employed for investigations on the age related physiological and biochemical changes. Results on the oxygen consumption of whole animals (Rao and Patnaik, 1973), changes in Ca/P molar ratio in long bones (Mishra *et. al.* 1971), the serum protein and haemoglobin (Patra *et. al.* 1972), the glycogen content of liver and skeletal muscle and the blood glucose level (Rao and Patnaik, 1971 ; Haseeb and Patnaik, 1973a ; Badal *et. al.* 1973) etc. reveal an augmentation upto a peak at a particular stage of maturity followed by a steady decline with advancing age. The age related declining trend in the solubility of collagen in skin, bone and hyoid cartilage was maximally marked during the early phase (immature to sexually mature stage) of growth, followed by slower changes thereafter (Patnaik and Padhi, 1972 ; Panigrahi and Patnaik, (1973). The total lipid and phospholipid contents of brain increase with advancing age but that of liver decline after reaching a peak level during early growth phase (Patnaik and Jena, 1972 ; Rao and Patnaik, 1972a). The loss of DNA concentration in liver and skin of the male garden lizard during the "early growth phase" has been correlated with a loss of cells by Rao and Patnaik (1972b) and Mishra and Patnaik (1973). But the same results will be apparently obtained if the DNA amount (per cell) remains constant and other biochemical components (protein, lipid and water etc.) increase in steady state concentrations (causing an increase in the wet and the dry mass of cells), even though the number of cells in the concerned tissue remains constant Similarly the conclusion of Haseeb and Patnaik (1973b), regarding the increase of protein "synthesis" in liver, skin and skeletal muscle upto a peak during full maturity and then a decline, seems to be far-fetched. Because, such observations on steady state concentrations of protein and RNA in a tissue, in absence of any investigation on labelled precursor incorporation into these macromolecules, can hardly be accepted as evidences of biosynthetic rates of the molecules. The steady state concentration of a molecule in a cell merely represents the level of accumulation, at any time, of this molecule, as a net result of the absolute synthetic and degradative rates.

Comparative and Adaptational Physiology

Often genetically diverse organisms demonstrate remarkable similarities in functional characteristics and response to the same environmental stimulus. On the other hand closely related species may sometimes respond divergently to their environment. The majority of the zoophysiologists in our country are apparently interested in elucidation of the diversity of animal functions and their adaptations to the changing environmental stress of varying nature from a comparative and sometimes a phylogenetic point of view.

1. Nutritional physiology : Although little work seems to have been done regarding the nutritional requirements of different animals (except insects, which have been reviewed elsewhere), a number of investigators have studied the physiology of digestion (digestive enzymes) and absorption in different invertebrates. Varute and More (1972) have explored the functional significance of lysosomal enzymes in the "chloragogen" cells of earthworm, particularly with regard to the intracellular digestion of food of plant origin and autophagy during starvation. The physiology of digestion of the crab, *Paratelphusa masoniana*, has been investigated with particular reference to the role of the mandibular gland by Tyagi (1970). Electrical potentials across the isolated intestine of cockroach (*Byrsotria fumigata*) have been measured under normal conditions and after metabolic inhibition by Datta (1971 and 1972). Besides, the absorption of amino acids and vitamin C through cockroach (*Periplaneta americana*) gut has also been studied by Datta and Maji (1971 and 1972). Rao (1972)has characterized the degestive enzymes of a limpet, *Cellana radiata* (Born). Varute and More (1971) have assayed the activity of β-glucuronidase in the digestive tract and liver and Varute and Sawant (1972) in the excreta of anuran tadpoles.

2. **Hematology** : The biochemical properties of respiratory pigments and their physiological significance, gaseous and ionic equilibria of blood and other physico-chemical properties of blood in the various tropical animals have attracted little attention of our zoologists. Parvathy (1972) has described the changing pattern of blood sugar level and its role in the synthesis of chitin during the moult cycle of crustaceans like *Emeria asiatica* and *Ligia exotica*. The blood cells of the freshwater mussel, *Lamellidens corrianus*, have been classified by Narain (1972b). The technique of a spectrophotometric estimation of haemoglobin concentration in the blood of fish (twelve fresh-water teleosts) using cyanmethemoglobin standard has been developed by Das and Agarwal (1972). The sexual dimorphism of bonnet monkeys in their hematological characteristic has been pointed out by Rahaman (1972).

3. **Cardio-vascular physiology** : The physiology and pharmacology of the heart in the fresh-water crab, *Paratelphusa masoniana*, has been investigated by Tyagi (1971). Narain (1971a and b, 1972a) has made a comprehensive study of the cardiac autorhythmicity (and myogenicity), the pharmacological properties of the heart and the possible involvement of the intrinsic cholinergic and tryptaminergic receptors in cardioregulation of the bivalve mollusc, *Lamellidens carrianus*. Alexander (1972) has made an attempt to correlate the differential distribution pattern of myoglobin in the various chambers of heart in some mammals with the varying physiological needs of the cardiae muscle in the different chambers. The maximal myoglobin content was observed in the left ventricle, with a decreasing order of myoglobin concentration in right ventricle, right auricle and left auricle. The minimal value of myoglobin in the left auricle may be plausibly correlated with the intraluminal oxygen diffusion. The higher levels of myoglobin in the ventricles may serve the higher oxygen (metabolic) demand by the ventricular muscles due to their forceful contractile activity. It is thus obvious that the electrophysiological investigations of heart and the haemodynamic parameters (blood volume, pressure and flow rate etc.) have not been conducted by our zoophysiologists.

4. **Respiratory metabolism** : The rate of oxygen consumption, as an index of the metabolic rate, and the influence of various intrinsic factors on this rate function have been studied in wide variety of tropical poikilotherms in our country. Mathur and Srivastava (1970) improvised an activity meter for determination of standard metabolic rate of fish. This is a modification of the flowmeter based on heat loss principle,

which was originally fabricated by Beamish and Mookherjii (Beamish. F. W. H. and Mookherjii, P. S. 1964. "Respiration of fishes with special emphasis on standard oxygen consumption. I. Influence of weight and temperature on respiration of goldfish, *Carassius auratus*.", *Can. J. Zool., 42*: 161-175). Joshi (1971) has used this device successfully for estimating the standard oxygen consumption and activity of the freshwater teleost, *Barbus stigma*. The relationship between the spontaneous activity and the oxygen consumption has been found to be linear (plotted on an arithmetic grid) and the standard oxygen consumption has been calculated by extrapolating the linear relationship to zero activity (the average value estimated for the fish is 50 mg. 0_2/Kg./hr.). A sexual dimorphism in the respiratory rate of the pteroctomized adults of the blow fly, *Lucilia cuprina*, has been detected by Verma (1970), when the measurement is done at 30°C. However, the difference between the two sexes seems to decrease with increase in temperature. The rate of oxygen consumption as a function of temperature has been estimated for the freshwater mussell, *Porryna carrugata*, by Nagabhushanam and Lomte (1971a). Rao (1971) has determined the effect of salinity on the standard and active rates of oxygen consumption of rainbow trout (*Salmo gairdneri*). The lowest rate is found in 7.5 p.p.m. salinity, which is approximately iso-osmotic to the plasma of the fish, probably because the osmotic load or cost of osmoregulation is the minimal in this medium. Influence of size, sex, temperature and seasonal changes on the rate of oxygen consumption has been investigated in the case of an agamid lizard, *Sitana ponticeriana*, by Rao and Rajabai (1972a). The increase of temperature has been found to increase the metabolic rate, but differently in the two sexes, in the summer and the winter populations, and in the small and the large sized populations. Tyagi (1973) has measured the effect of variation of pH on the respiratory rhythm of the carb, *Paratelphusa masoniana*. Reddy (1972), and Rao and Rajabai (1972b) have recorded circadian rhythms of respiratory rates in scorpion and garden lizard, respectively.

5 **Nitrogenous excretion and renal physiology** : The molecular weights of arginase from a number of different species of urotelic animals have been compared by Raghupathiramireddy and Campbell (1970). Almost no work has been done during the last three years either on the nature of the nitrogenous excretion in different animals or on the renal physiology of the vertebrates. However, the presence of β-glucuronidase activity has been reported in the excreta of anuran tadpoles by Varute and Sawant (1972).

6. **Osmotic relations :** Varying responses of animals to osmotic changes in the aquatic environment and the mechanisms and bioenergetics of osmoregulation have been analysed chiefly in Crustacea (Nagabhushanam, 1971b; Nagabhushanam and Chinnayya, 1970; Nagabhushanam and Kulkarni, 1970), one species of freshwater bivalve Mollusca (Nagabhushanam and Lomte, 1971b) and an euryhaline teleost Pisces (Pandian and Raghuraman, 1972).

7. **Comparative neurophysiology and sensory physiology :** Electrophysiological researches concerning neurophysiology and sensory physiology in an arachnid (scorpion) was pioneered by the late Prof. K. P. Rao in S. V. University, Tirupati and later in Bangalore University, Bangalore. The unit motor activity in the ventral nerve cord of the scorpion, *Heterometrus fulvipes*, recorded by Venkatachari and Babu (1970), the central course of hair afferents (sensory nerve fibres from hair cells) and the pattern of contralateral activation nervous system (CNS) of this scorpion investigated by Sanjeevareddy and Rao (1970), the relationship between stimulus modality and innervation pattern of this scorpion's hair sensillum established by Sanjeevareddy (1971), and the presence of interneurons in the CNS of scorpion proved by Babu and Venkatachari (1971) are the examples. Investigations on the effect of temperature on proteins and amino acids of the cephalothoracic mass of scorpion, conducted by Habibulla (1971), is an example of neurochemical work.

Excellent electrophysiological studies have been conducted by Dr. R. Singh (C. I. B. R., Amsterdam, and Jaipur) on the rat brain cortex. Singh (1971) has studied the effects of some cerebral circulatory drugs (nicotinic acid, cyclospasmol and ronicol) on the cortical electroencephalographic (EEG) activity of rat and has observed that nicotinic acid induced a sleep like electrical activity (and behavioural pattern), the onset of which may be related to the suggested nicotinic acid induced decrease in cerebral blood flow. Besides, Singh (1972) has also reported on the computer analysis of the rat EEG activity and has investigated the correlation between the visual EEG patterns and their autocorrelograms and Fourier frequency displays. The brain electrical activity of wakefulness following nicotinic acid administration shows a marked degree of autocorrelation in EEG, thus indicating some synchronization in neurophysiological activity.

8. **Comparative muscle physiology :** Dr. K. M. Alexander of University of Kerala, Trivandrum, has made pioneering work on the biochemistry of

molluscan muscles. A comparative study of the distribution pattern of myoglogin in different muscles of some gastropods such as *Pila virens*, *Vaginulus* sp. and *Limax* sp. has been made by Alexander (1970a) and it has been found that the highest myoglobin content is exhibited by the radular muscles of *Pila*. Suryanarayanan and Alexander (1971a) have demonstrated that the pallial muscles of both gastropods and bivalves serve as glycogen storing tissues. The grey (fast) and white (slow) muscles of adductors of *Lamellidens corrianus* (comparable to the red and white muscles of vertebrates) exhibit distinct variations with regard to the glycogen yield. Paradoxically, however, the cephalopod muscles have been found to possess very low level of glycogen content. The distribution pattern of lipids in molluscan muscles (except adductors) does not present a significant variation. The effects of mammalian insulin on the glycogen reserves of pedal muscles (and midgut gland) of the gastropod, *Pila virens*, have been investigated by Suryanarayanan and Alexander (1971b). Insulin tends to boost the glycogen concentration of pedal muscle within one hour of administration, after which the glycogen level declines and returns to the normal value. Conversely, the midgut gland loses glycogen steadily after administration of insulin, reaching a minimal value in an hour, after which the normal value is restored. Obviously an instrinsic regulatory mechanism operates for the maintenance of glycogen levels in both midgut gland and pedal muscles. Suryanarayanan and Alexander (1973) have also reported on the biochemical features of the red muscles, radular and triturative stomach muscles of the gastropod, *Pila virens*. In higher contents of glycogen, lipid, myoglobin, iron and phosphorus, the red muscles of *Pila* are physiologically comparable to the vertebrate red muscles. Besides the molluscan muscles, Alexander (1070b) has also studied the biochemical composition of fish muscles, with particular reference to the distribution of lipids in muscles from the different body regions of two teleosts, *Arius dussumeri* and *Ophicephalus striatus*. A significant dorsoventral gradient in lipid content is exhibited by both these fishes, with higher lipid yields from the ventral muscles (especially the belly flaps). Besides, the dorsal aspects of the caudal region and anterior portion of the dorsal fin area have muscles richer in lipid concentration, while cephalic and mid-trunk regions have low lipid containing muscles.

Kallapur (1972) has investigated the lipolytic activity in the flight and leg muscles of the dystiscid beetle, *Cybister confusus*. Developmental physiology of muscle in relation to embryonic and post-embryonic differentiation has also been explored with particular reference to the Chicken fast and slow skeletal and cardiac muscles (Radha, 1972).

Obviously the biophysical studies on the mechanical and electrophysiological properties of muscles have not attracted the attention of zoologists.

9. Pigments and colouration : Verkey and Alexander (1971) have studied the background responses of the melanophores of teleosts, *Macrones chryseus* and *Saccobranchus fossils*. The initial phase of colour change is through neural mechanism, with hormonal factors coming into play in the final stages, in the case of *Macrones*. However, in *Saccobranchus*, the response is a slow and a gradual process without any possible neural mechanism. The main receptors for colour change, in both the teleosts, are eyes. George and Alexander (1971) have made a comparative study of the myoglobin content in the leg muscle, adductor longus pars interna, of male demestic fowl belonging to three breeds (White Leghorn, Rhode Island Red and Black Indian country fowl). The lowest myoglobin content is found in the White breed and the highest value in the Black one, with the Red breed having an intermediate value. Quite plausibly the myoglobin synthesis is related to the colour of an animal. Similar studies on white, brown and black Indian country goats and oxen yielded comparable results.

10. Thermal adaptation : The mechanisms of adaptation to high and low temperatures of the environment have been studied in wide variety of tropical poikilotherms. Nagabhushanam and Lomte (1970) have investigated the "resistance" acclimation (of Precht) to high temperature of *Porryna corrugata* (a bivalve mollusc). Insects have attracted relatively a few investigators interested in the physiology and biochemistry of thermal adaptation in poikilotherms. Das and Singh (1972b) have prepared an excellent review on the researches done in this field. A remarkable capacity of metabolic compensation (25—60%) against alteration of temperature (measured in the rate function of oxygen consumption) is exhibited by the coxal muscle of nymphs and both the sexes of adults of *Periplaneta americana* (Das and Singh, 1970). Besides, an augmentation of protein content (67% in nymphs, 16% in males and insignificant in females) and of RNA/DNA ratio (15—30% in nymphs and males but not in females) also characterizes the cold acclimation of coxal muscles in this insect. The fat body of cockroach undergoes a remarkable histomorphological transformation due to cold adaptation, as a result of heavy deposition of lipo-protein reserve materials (175% increase in protein/DNA ratio) in the form of granules or globules (Das and Singh 1972a). A lobule of the normal "foliate" fat body is thus metamorphosed into a large "capsule" with noncellular matrix loaded with refractile globular inclusions in 15°C acclimated roaches.

A critical review of the known mechanisms of thermal acclimation of poikilotherms has been prepared by Parvatheswararao (1972b). The tropical freshwater teleost, *Etroplus maculatus,* exhibits "complete compensation" in brain, "over-compensation" in liver and poor or "no compensation" in skeletal muscle with regard to the respiratory rate during thermal adaptation (Parvatheswararao, 1972a). There is coincidence between the whole fish and its brain in the type ("complete compensation" or Prechts' type-2) of thermal acclimation in metabolic rate and this may suggest an important role of the central nervous system in the regulation of the compensatory processes at the level of the entire fish.

Metabolic compensation to seasonal thermal changes has been demonstrated in the case of *Etroplus maculatus* by Pravatheswararao (1971). At the acute temperatures, "winter" fish consumed more oxygen than "summer" individuals, and at the respective habitat temperatures both "winter" and "summer" populations consumed oxygen almost at the same rate despite the wide difference in temperature. Das (1971) has also shown the seasonal biochemical acclimatization to occur at the molecular level of different tissues in *Channa panctatus*. The steady state concentrations of total protein, free amino acids, RNA (or RNA/DNA ratio) and glycogen increase in liver, gill, brain and skeletal muscle of the fish with the approach of winter and decrease in summer. Muralimohan *et. al.* (1972) studied the aestivation metabolism of *Pila globosa* (gastropod mollusc) with reference to nervous system. The electrical activity patterns and acetylcholinesterase kinetics indicate an inhibitory glutamate sensitivity during aestivation.

Rao and Rajabai (1972) attempted to acclimate the ground dwelling agamid lizard, *Sitana ponticeriana* (Cuvier), to 20°C and 35°C and estimated the rate of oxygen consumption of the "cold" and "warm" animals at 15°, 20°, 25°, 30°, 35° and 40°C. Their data reveal a complete lack of metabolic compensation against habituation of the lizard to a high and a low temperature. However, the authors have surprisingly concluded that,"............acclimation by translation was common and the type of acclimation is dependent on the size of the lizard also".

11. Osmotic adaptation : A comprehensive review of the known mechanisms and bioenergetics of osmotic adaptation in fishes (teleosts in particular) has been prepared by Parvatheswararao (1970). Alterations in the levels of blood glucose, liver and muscle glycogen during osmotic adaptation of

Tilapia mossambica have been described by Basamohideen and Parvatheswararao (1972).

12. **Parasitic adaptation** : Physiology and biochemistry of parasites are almost unrepresented in the spectrum of reasearches in adaptational physiology conducted in the Zoological laboratories of India. Monohar *et. al.* (1971), however, have observed significant shifts in amino-transferase activity and total free amino acid concentration in *Lymnaea* during trematode infections. The significance of such changes is not yet known.

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ENDOCRINOLOGY OF THE VERTEBRATE REPRODUCTION

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The objectives of studying the endocrinology of reproduction are 1) for the limitation of fertility of fast-increasing human population, 2) for the promotion of fertility of economic animals and (3) for academic interest particularly for a better understanding of the evolutionary process. In our country also, the reproductive biologists are exploring these aspects with considerable success.

An attempt has been made in the following pages to take an inventory of the studies in the domain of reproductive biology recorded by the Indian scientists during 1970-1973. This is not claimed to be a complete record and it is fully realized that some important contributions may have skipped our eyes. This coverage, however, provides enough data to indicate the brisk progress of this important branch of science in India during the period under review.

In the present endeavour my collaborator Dr. B. R. Maiti, took a responsible part and the compilation of this review, therefore, is being presented as a joint effort. The authors are extremely grateful to many colleagues who have promptly responded by supplying materials for inclusion in the present review.

MAMMALIAN

NEURO-ENDOCRINE CONTROL

Anand Kumar (1971) through his exhaustive studies has shown that 'tanycyte' ependymal cells undergo dramatic changes in consonance with the different stages of the menstrual cycle and changes in the endogenous levels of estrogen. His findings bespeak of a functional link between the hypothalamus and the adenohypophysis *via* a 'non-neuronal' cellular system, Saxena and his associates have studied the neuroendocrine control of reproduction in rats and found that higher concentration of circulating androgen affects certain hypothalamic physiotropic areas specially located around the third ventricle and inhibit both synthesis and release of GTH-RF and the synthesis of pituitary gonadotropins directly, while low concentration of androgen stimulates both synthesis and release of hypothalmic RF with no effect on the pituitary gonadotropins. A very high concentration of gonadotropins inhibits the release of GTH-RF from the hypothalamus without affecting their synthetic process (Saxena, 1970, 1971).

Kulshreshtha and Dominic (1973) investigated the changes in the HNS of the musk shrew induced by gonadectomy and suggested that the hyperactivity observed in the neurons of the SON and PVN of short-term castrates may be due to the decreased level of gonadal hormones or to the increased gonadotrophic activity following gonadectomy. Kulshreshtha and Dominic (1971, 1972) reported an aggregation of mast cells in the median eminence, in close contact with the primary capillary plexus of the hypophysial portal system. They suggest that these cells may be influencing the discharge of the hypothalamic neurohormones into the capillaries in the median eminence.

BIOCHEMISTRY OF GONADOTROPINS

Duraiswami along with his associates while studying biochemistry of gonadotropins has isolated a pituitary glycoprotein fraction from the sheep which shows dual gonadotropic activity. In terms of biological activity P1-2 fraction of the pituitary possesses both FSH and LH activity and is twice as active as the standard NIH-LH preparation. On the basis of OAAD assay it is one and a half times as active as the LH standard. FSH potency of the same fraction is only 40% of that of the ovine FSH standard. It is suggested that P1-2 fraction of the ovine pituitary is indeed an FSH—LH complex showing monodisperse behaviour and the biological activity of P1-2 is dependent upon the integrity of its (quarternery) structure and is considerably modified following dissociation (Duraiswami and Sreemathi, 1971 ; Sreemathi and Duraiswami, 1972 ; Sreemathi *et al.*, 1971).

OVARY AND OVULATION

Guraya (1971 and 1973) has published two excellent reviews on the interstitial gland tissue of mammalian ovary and also on the histochemistry and biochemistry of the human ovary.

Naik and Dominic (1970) studied vaginal cell types, sexual receptivity and the mating behaviour of the musk shrew (*Suncus murinus*) in capitivity. They have identified five morphologically distinct cell types in the vaginal smears and did not find any variation in the proportion of these cells alongwith different stages of the estrous cycle. Hence the precise length of estrous cycle of the musk shrew cannot be determined by examining the vaginal smear. Evidences point out that the species in an induced ovulator.

Zala and others (1972) have found that during day 9 through 13 of estrous cycle in Surti Buffalo Heifers ascorbic acid and cholesterol contents of the adrenal glands were declined.

Roy and his associates (Kumari *et al.*, 1971) have shown that administration of glucocorticoid once daily, at about midnight, to anovulatory women induces ovulation in some. In all likelihood, the glucocorticoid (dexamethasone) suppresses the early morning surge of ACTH release and thereby inhibits the secretion of abnormal sex steroids from the adrenal cortex, thus relieving the pituitary-gonadal axis and permitting the release of gonadotrophin. To test this hypothesis further, urinary estrogens have also been measured.

HORMONAL CONTROL OF IMPLANTATION

In experimentally induced delayed implantation of the blastocysts in rats estradiol augments RNA synthesis by activating cyclic AMP and treatment of dibutyryl cyclic AMP mimics action of estrogen by accelerating RNA synthesis (Mohla and Prasad, 1970). It has been further substantiated by Mohla and others (1970), Mohla and Prasad (1971) and Prasad and others (1972), who used radioactive uridine, thymidine and phenylalanine for demonstrating enhanced RNA, DNA and protein synthesis in delayed implantation of the blastocysts in the same animals. Rajalakshmi and others (1972) have pointed out importance of sialic acid in implantation of the blastocyst in early pregnancy in rats.

Clomiphene, CN-55, MER 25 and DMS act as antiestrogen by inhibiting the uptake of labelled estrogen by the estrogen sensitive target tissues and these antiestrogenic compounds act by competing with natural estrogens for common receptor sites in the target organs and once they occupy the receptor sites in the target organs they prevent the natural estrogens from reaching the sites (Prasad, 1970, cf. Karkun and Mehrotra, 1973). Compound like U-11, although does not affect the uptake of labelled estrogen, it inhibits uptake of ^{32}P into DNA, RNA and protein. This antiimplantation action of the compound may be due to interference with an estrogen-dependent RNA and protein synthesis. In general antiimplantation effect of several antiestrogens may be suggested to be due to various reasons such as, (i) by increasing tubal or uterine motility resulting in the expulsion of ova or blastocyst, (ii) causing toxicity to the viability of ova or blastocyst, (iii) inhibiting estrogen uptake by the uterus, (iv) interfering with decidualisation, (v) inhibiting histamine action, (vi) inhibiting decidual cell response by blocking estrogen-dependent enzymes or nucleo-protein synthesis (Sankaran *et al.*, 1971 ; Sankaran and Prasad, 1971, 1972a, b ; Prasad and Sankaran, 1972).

SEX-STEROIDAL EFFECTS ON FEMALE GENITAL TRACT AND LIVER

A comparative assessment of the histobiochemical response of uterotubal junction (UTG) and uterus to changing concentration of endogenous estrogen and progesterone was studied in pregnant rabbit during 14 to 168 hours post-coitum (Gupta *et al.*, 1971). Certain broad similarities were noticed in the response of the two organs. However, the marked changes in the level of lactic acid and acid phosphatase activity were conceived to be related respectively to metabolism of ova and the removal of dead sperm and denuded cellular debris. The different parts of the Fallopian tube were found to incorporate estradiol—17β, 6, 7^3-H at a much higher rate than the other parts e.g., uterus, vagina, etc. of the rabbit genital tract. Isthmic uptake of the labeled steroid was highest of all the tubal parts and was believed to be related with its more powerful contractility (Roy *et al.*, 1972a, b). Mehrotra and Karkun (1973) observed the stimulatory signs with increased weight, thickening, keratinization and desquamation of the surface epithelium and edematous stroma of the cervix and vagina of rats treated with estradiol dipropionate (EDP) once daily for 4 weeks. This pattern of changes were also true with testosterone to a certain extent but not with progesterone.

Paul (1970) studied the effects of Enovid (norethynodrel plus mestranol) treatment on the hepatic nucleic acids, proteins and lipid content of the female rat. The study suggests that long-term treatment with enovid can adversely affect hepatic RNA and protein levels and also it can cause excessive accumulation of lipids in this organ. Paul (1971a and b) studied the effects of continued estrogen administration in the intact or ovariectomized rat on the uterine glycogen and its contractile nature as compared with normal pregnant animals. He points out that estrogen induces some ovarian factors (progesterone ?) to antagonize the glycogenic and contraction-stimulating effects of estrogen in the uterus. The uterine growth and glycogen accumulation which occur during pregnancy are probably due to a release o local placental hormones. In another study, the author suggested that continued estrogen treatment to non-pregnant rats probably maintains some endogenous factor(s) for about 21 days, which antagonizes the effect of estrogen on hepatic glycogen deposition. The increase in hepatic total glycogen up to mid-term pregnancy appears to be due to the increase in food intake (Paul, 1972). From this investigation, it was concluded that the glycogenic effect of estrogen in the liver and uterus of the ovariectomized rat is inhibited by progesterone and the latter is inhibitory to uterine and hepatic glycogen accumulation. This glycogenolytic action of progesterone occurs in the presence of hyperphagia and hyperglycemia (Paul and Duttagupta, 1973).

HISTOMORPHOLOGY AND BIOCHEMISTRY OF THE MALE GONAD

In recent years Mathur and his associates have made histomorphological and histochemical studies on the cycling testes and the accessory reproductive glands of the *Suncus* (Mathur and Goyal, 1972). *Suncus*, provides perhaps one of the outstanding example of individual variations in the size of the accessory glands, and totally lacks the ampullary gland. The seminal vesicle possesses only the secretory functions and it is anatomically impossible for it to harbour any sperm. It has also been observed that in *Suncus*, ventral prostate is the main source of the citric acid, seminal vesicles are the main fructose producers and both the Cowper's gland and the dorsal prostate secrete high concentrations of sialic acid. The effect of androgen on the enzyme system of the testes of *Meriones* reveals that nonspecific esterases and dehydrogenases show a decline and inhibition in the spermatogenetic cells. The results further suggest that ATPase could be one of the key enzymes for the regulation of the spermatogenetic phenomenon (Singh and Mathur, 1970). Furthermore, both qualitative and quantitative variations in the enzyme activity could be highly significant and are attributable to a combination of age and strain differences (Mathur, 1971). Male rats receiving TP both neonatally and when adult had significantly heavier penis, levatorani muscles and seminal vesicles. Total nucleic acid i.e., RNA and DNA increased more rapidly in early androgenized animals as compared with early oil-treated males (Dixit and Niemi, 1973).

HORMONAL AND CHEMICAL EFFECTS ON PROSTATE

Effect of altered hormonal conditions upon the histochemical distribution of nucleic acids, protein, polysaccharides, lipids, succinic acid dehydrogenase and mast cell population of rat prostatic complex were studied by Takkar and collaborators (see Takkar and Kamboj, 1971). A single injection of cadmium chloride, selenium dioxide and strontium chloride reduced both the free and protein-bound zinc concentration in the rat dorsal prostate without causing any change in their distribution patterns in the subcellular fractions (Chowdhury *et al.*, 1971). The role of hormonal status of the animal on the incorporation of estradial 6, 7^3-H(E), testosterone-1, 2-^{3}A (T) and dl-valine-1-^{14}C (V) *in vitro* by the prostate was studied in prepuberal rhesus monkey by Roy *et al.* (1971). Castration increased the incorporation of estrogen and testosterone but decreased that of radioactive valine. Thyroxine, in contrast, decreased all of them. In castrated-thyroidectomized animals with or without triiodothyronine (T_3) supplementation, only T uptake was stimulated; incorporation of E^3 and V were reduced in the group subjected to T_3 therapy.

CHEMICAL INTERFERENCE WITH FERTILITY

Rajalakshmi and Prasad (1971) have studied the sialic acid content in the epididymis of the puberal rats and found that it reaches the peak in the caput and cauda epididymis between days 40-45 prior to the entry of sperms into these regions. Following the entry of sperms, sialic acid level sharply declines till day 60 in the caput part, while the decline is transient between days 45-50 and followed by sharp rise at day 60 in the cauda epididymis Ligation of efferent duct causes marked decrease in sialic acid content in the caput epididymis only. Sialic acid is also reported to be declined from both the epididymal parts in cryptorchidised rats or in ORF 1616 or cyproterone acetate treated rats. Prasad (1972) has demonstrated that cyproterone acetate in silastic capsule when implanted in the body is released in very low amount (232 μg/day) can inhibit maturation, motility or fertilizing ability of the spermatozoa while passing through the different regions of the epididymis without affecting much to the spermatogenetic process or androgen production or sexual libido. He has suggested that this compound acts mainly by interfering with some androgen-dependent secretory activity of the epididymis. Prasad has also found that testosterone in very low amount (138 μg/day) when released from the implanted silastic capsule, can also inhibit fertility of male rat by suppressing spermatogenesis and to some extent Leydig cell function, maintaining other sexual activities to almost a normal level and has pointed out to be due to inhibition in the secretion of LH. However. following withdrawal of cyproterone acetate or testosterone, fertility can be restored.

Progesterone (1 and 2, 3 mg dose/rat/day), administered for 30 days had no effect of testicular spermatogenesis or the Leyding cells but exerted an antiandrogenic effect on the accessories (Jehan *et al*, 1970). Chatterjee and Ray (1972) observed that cadmium at a moderate dose level had differential deleterious effects on the scrotal and cryptorchid testes in the same individual at the end of 72 hours. Further Ray and Chatterjee (1973) also observed that in the reserpine-primed or adrenalectomized rats cadmium failed to induce any detrimental effects in either of the testis irrespective of the scrotal or intra-abdominal position. They concluded from these findings that cadmium is injurious to the vascular endothelium only when an appropriate amount of catecholamine is available.

Jacob and Kaul (1973) have evalauted 3 newly synthesized nonsteroidal derivatives of chalcone (benzalacetophenone) viz, 2′ chloro-4-4'-difluoro chalcone (CH-4), 2'-chloro-3:4-methylenedioxy-4'-fluorochalcone (CH-6) and 2'-hydroxy-3:4-methylenedioxy-4' fluorochalcone (CH-8) for their estrogenic and antifertility effects in the mouse. All the three compounds possess uterotrophic effect. Since CH-6 possessed the highest uterophic effect, postcoital treatment of CH-6 inhibited implantation in the mouse. In the male mouse CH-6 caused a decrease in the weight and size of the testes and the seminal vesicles. Sharma and others (1973) have reported that lanthanum chloride, yitrium nitrate and thorium oxalate caused progressive calcification of both seminiferous tubules and interstitium, the effects being augmented by calciferol sensitization. Calcium deposition did not appear related to tissue necroses, all induced acute sterility in rats. Dasgupta and collaborators (1970) have found inhibition of motility of spermatozoa and their eventual death were caused by exposure of such sperm to aqueous solution of urea in as low as 0.06% concentration. Urea in sodium carboxymethyl cellulose also caused such inhibition of sperms, suggesting its use as a potential vaginal contraceptive.

Kasinathan *et al* (1972) studied the antifertility effect of *Ocimum sanctum* in mice. Biochemical studies revealed that there is a lowering of pH, decrease of mucoprotein and increase of acid and alkaline phosphatases. Experimental males failed to fertilize. The sterility thus produced may be due to physical changes like decrease of pH, hypertonic environment and differences in concentration of chemical substances of biological importance.

Investigations of Paul *et al.* (1973a and b) indicate that an acute dose of biotin can induce sterilizing effects in the female rats. This antifertility effect of biotin can effectively be ameliorated by estrogen treatment.

A group of scientists from endocrinology division of the Central Drug Research Institute at Lucknow have evaluated large number of streoidal and non-steroidal compounds producing antifertility effects in both male and female laboratory mammals and primates during the period of present review. Only selected references have been cited at the end of the chapter (Gopalchari *et al.*, 1971 ; Setty and Kar, 1972 ; Singh *et al.*. 1972 ; Dasgupta *et al.*, 1972).

RADIO-CHEMICAL EFFECTS

Chadha and Srivastava (1970) while studying the effect of P-32 during gonad development in the mouse have found a marked reduction in the size and weight of the ovaries during all the developmental stages and absence of the primordial secondary and tertiary follicles. In the male, reduction in the size and weight of the testes was noted which was coincident with the reduction in the diameter of the seminiferous tubules. Type B spermatogonia and resting spermatocytes were most radiosensitive. Type A showed reparation at a faster rate than the other germ cells. In the 3-week injected animals testes were severely affected and no signs of reparation were witnessed even after 6 weeks. For exhaustive references on the effect of radiophosphorous on mice gonads, the reader is referred to a recent review by Srivastava (1972).

MOLECULAR BIOLOGY OF STEROID ACTION

Contraceptive steroid : It has been shown that ^{3}H-norethynodrel and its metabolites after an injection in rats, are rapidly taken up in the uterus, ovary, pituitary and hypothalamus with an initial rapid disappearance followed by slow clearance, Similar pattern of uptake and disappearance was found in rats administered with ^{3}H-chlormadinone acetate (Laumas *et al.*, 1972). A very high uptake of ^{3}H-chlormadinone acetate was found in adipose tissue. Contraceptive steroids like ^{3}H-chlormadinone acetate and ^{3}H-norgestrel after an i.v. injection to women showed an initial rapid disappearance and a subsequent slow disappearance from the plasma. The half life of these steroids in plasma was found to be higher than that of estradiol and progesterone. The metabolic clearance rate (MCR) of norethynodrel and its metabolites was found to be 30 litres/day (Laumas *et al.*, 1971a). The MCR of chlormadinone acetate and norgestrel was 126.6 litres/day and 458.5 litres/day respectively (Dugwekar *et al.*, 1973). Between endometrium and myometrium more of the steroid is present in the endometrium, indicating of a selective retention of the steroids in the the endometrium of women. Chlormadinone acetate showed very high uptake in the fat compared to norgestrel. Studies on the subcellular localisation by ^{3}H-norethynodrel in the rat uterus and human endometrium showed that nearly 60% of the steroid was present in the 105,000 x g supernatant fraction while about 30% was localized in the nuclear fraction. The norethynodrel localized in the cytoplasmic fraction binds to a receptor protein (Laumas *et al.*, 1971b). The results thus suggested that specific binding of the contraceptive steroids with uterine receptors may be one of the important step in the action of these steroids in the uterus.

Estrogen : The uptake and tissue protein binding of diethylstilbestrol, a potent estrogenic compound to rat uterine cytosol was studied (Laumas, 1970). This study resolved quite a few similarities between estradiol and diethylstilbestrol in their uptake and binding pattern, Laumas and his associates (1972) have shown the priming effect of oral progestins like norethynodrel on the uptake of estradiol. At low doses (5 μg) the progestin stimulated the estradiol uptake in the mouse uterus and at high doses of 50 μg norethynodrel produced an inhibitory effect on the estradiol uptake in the uterus. Similarly the effect of another oral progestin chlormadinone acetate on the uptake of estradiol was shown by Laumas and others (1973). It was suggested that these oral progestins may compete for estradiol binding sites in the uterine receptors. Analysis of the bound steroids revealed that both estrone and estradiol were associated with the binding protein. Competition studies showed that estrone and diethylstilbestrol compete greatly for the estradiol binding sites (Krishnan *et al.*, 1973a). An extensive study was carried out on the metabolism, and interaction of estradiol in endometrium, myometrium and Fallopian tube. Biotransformation of 6, 7-^{3}H-estradiol 17β by human proliferative and secretory endometrium and the myometrium resulted in the formation of estrone (Krishnan *et al.*, 1971). Conversion was more by the endometrium than by the myometrium and it was more in proliferative state than in the secretory state. Rabbit endometrium, myometrium and different regions of the Fallopian tubes converted estradiol to estrone (Krishnan *et al.*, 1972). Ovariectomy, pseudo-pregnancy and progesterone treatment decreased the rate of estradiol to near normal levels. Chlormadinone acetate (0.2 mg) pretreatment reduces the metabolism of estradiol by rabbit endometrium and not by myometrium (Krishnan *et al.*, 1972).

Progesterone : An extensive study on the subcellular distribution and binding of progesterone to the human uterine proteins was carried out. Of the four fractions, viz. nuclear, mitochondrial, microsomal and cytosol, the nuclear and the cytosol fractions concentrated major steroid than the mitochondrial and microsomal fractions. The endometrial and the myometrial progesterone binding protein had sedimentation coefficients of 4.55 and 4.1 S respectively (Verma and Laumas, 1973). Analysis of the bound steroid revealed that along with progesterone, small amounts of its metabolites were also bound to the receptor protein. Among the steroids studied 5α-pregnane-3-20-dione showed the highest competition for progesterone binding sites unlike the progestational steroids viz. noregestrel and chlormadinone acetate.

PROSTAGLANDINS

Chatterjee (1972a) investigated the mode of action of prostaglandins in rat. He showed that the administration of PGF2a on day 5 of pseudo pregnancy (day of uterine traumatization) caused luteolysis as well as lysis of the deciduoma within 72-96 hours. But when the treatment of PGF2a was deferred to day 6, 7 or 8 of pseudopregnancy instead of day 5, the regressive changes were found to be relatively less intense. However, an exogenous replacement with prolactin or hydroxyprogesterone caproate for 4 consecutive days (day 5 to 8) very successfully prevented the luteolytic effects of PGF2a. He concluded that the antidecidual effect of PGF2a at this selected experimental dose level is probably mediated through a lowering of circulating level of endogenous prolactin (*vide* also Chatterjee, 1972c). Chatterjee (1972b) suggested that the failure of PGF2a to reverse the compensatory phenomenon in the surviving ovaries is definitely through a alternative mechanism of PGF2a-induced luteolysis other than the exclusive phenomenon of restricted blood supply to the ovaries during pregnancy (also compare Chatterjee, 1973b). Abortificiancy of PGF2a in rat may possibly be intervened through the hypothalamo-adenohypophysial system (Chatterjee, 1973a).

PHEROMONES

Dominic (1971a) has demonstrated that ovo-implantation is blocked in newly mated mice at a higher frequency when exposed to stud male of different strain than when exposed to stud male belonging to the same strain. This differential response is suggested to be due to the genetic difference between the odours of the urine of stud males of similar and dissimilar strains. Dominic (1971b) in another experiment has developed a new technique for inducing synchronized matings in female mice which would enable to obtain large numbers of mated females at a time and to minimise labour, space and equipment. Dominic (1972) found that although normal female mice are incapable of blocking the pregnancy of newly mated females, the capacity to block pregnancy is induced in androgenized females. In the induction of the pregnancy block exposure to androgenized females or their urine provides a stronger stimulus than exposure to normal males or male urine.

AVIAN

PHOTO-THYRO-GONADAL RELATIONSHIP

Thapliyal and his associates have made significant contribution in an important area of avian reproductive biology, viz., the photoperiodism and thyro-gonadal relationship in Indian birds. Results of light and/or thyroidectomy or L-thyroxin injection experiments indicate that while day length regulates the sexual cyele of male weaver bird, *Ploceus philippinus* (Thapliyal and Bageswar, 1970) ; thyroid controls the annual gonadal periodicity in both the sexes of nonphotoperiodic spotted Munia, *Lonchura punctulata* (Pandha *et al.*, 1973 ; Chandola and Thapliyal, 1973) and Lal Munia, *Estrilda amandava*. In photosensitive Black-headed (*Munia malacca*) and Chest-nut bellied (*Munia atricapilla*) Munias and female Weaver bird, however, both the thyroid and light seem to contribute in timing the periodicity (Chandola, *et al.*, 1973).

Effect of growth hormone and prolactin on the body weight and thyroid function of the Spotted Munia has been studied by Chandola and Thapliyal (1972). It is observed that both the hormones increase the body weight of birds. In thyroidectomized birds, while growth hormone fails to produce a gain in body weight, prolactin becomes significantly effective.

DRUG EFFECTS ON MALE GONAD

Sarkar and Mukherjee (1973) noted an overall degeneration of seminiferous tubules as well as gonadal accessories in reserpinized pigenons. Sarkar and Mondal (1973) claim of a protective action of the zinc in cadmium-treated gonads of the adult male pigeons.

REPTILIAN

ADENOHYPOPHYSIAL CONTROL OF SPERMATOGENESIS

Prasad and his associates have studied the sex hormonal control of spermatogenesis mainly in *Hemidactylus*. They have shown that FSH may be the only gonadotropic hormone involved in the maintenance of spermatogenesis as well as androgen-dependent sexual segment of the kidney in the lizard and suggested that FSH also stimulates androgen production in the testes of *Hemidactylus*. These authors further demonstrated that the concentration of total lipid, total glyceride (triglyceride as major fraction) and total cholesterol of the testis is low during the active season (November-April) and reaches a peak when the testes are regressed (June-July). Total phospholipid (phosphatidylcholine and phosphatidylethanolamine as major fractions) is high during the spermatogenetically active season and is low during the regressed season. Hypophysectomy brings about changes in these lipid fractions similar to those observed in non-breeding season. Accumulation of glyceride during non-breeding season or following hypophysectomy may be due to the inhibition of the enzyme phosphorylcholine transferase (Reddy and Prasad, 1970a, b, 1971 ; Reddy *et al*, 1972a, b ; Prasad and Reddy. 1972).

SEX STEROIDS

Upadhyay and Guraya (1972) by their histochemical study on interstitial gland cells of testis of lizards (*Varanus bengalensis* and *Mabuya macularia*) indicated that these cells are steroid secretors and they bear resemblance in their histochemical features with the steroid producing cells of mammalian testes and ovary. Kasinathan *et al.* (1973) reported that in the *Calotes* testis, testosterone and 17β-estradiol were detected, while progesterone was absent. Kasinathan and Basu (1971) found increased potassium and decreased sodium level in muscles and blood serum of the *Calotes* following administration of androgen and estrogen.

THYROIDAL INFLUENCE

Thapliyal and Chandola (1973) reported seasonal variation in thyroid hormonogenesis in the Indian garden lizard, *Calotes versicolor*. Further, it has been found that oxygen consumption was decreased in thyroidectomized and castrated *Calotes* and increased significantly in thyroxine—and male hormone-treated lizards (Chandola *et al.*, 1973a). In another study involving the same species a significant dependence of thyroid function on male hormone has been reported (Chandola *et al*,, (1973b).

AMPHIBIAN

HORMONAL STUDIES OF TESTIS

Kasinathan and Basu (1971) stated that spermatogenesis is inhibited at the secondary spermatogonial level in *Rana hexadactyla* by testosterone treatment but one month after extraction of the testosterone pellet, the spermatogenetic processes had recovered indicating direct action of exogenous testosterone on testicular tissue. Further these authors (1972) have reported that spermatogenesis was usually accelerated by pituitary extract administered at any time of the year, although the effect was more pronounced in frogs treated with summer pituitary extracts during summer time than in winter. This proves that the gonadotropin secretion of the hypophysis depends on the external environmental conditions which in turn sensitizes the germinal epithelium alone in conjunction with the internal physiological rhythm. Kasinathan *et al.* (1973) have analysed the gonadal steroids of *Rana hexadactyla*, *Rana cyanophlyctis* and *Rhacophorus maculatus*. In the testes of all the three species of frogs studied, testosterone was significantly absent ; progesterone and 17β estradiol were detected.

Thyagaraja and Sarkar (1970 and 1973a) demonstrated compensatory testicular hypertrophy in the toad, *Bufo melanostictus* and in the frogs, *Rana hexadactyla* and *Rana tigrina*. The same authors (1972 and 1973b) also demonstrated that both testosterone and progesterone are able to block testicular compensatory hypertropy in the hemicastrated toad, *Bufo melanostictus*, whereas corticosteroids like deoxycorticosterone acetate and hydrocortisone maintain testicular hypertrophy.

Chatterjee and his collaborators (1971) showed experimentally that exogenous administration of HCG in hypophysectomized male toads (*Bufo melanostictus*) could be able to induce spermiation quite successfully similar to that of the intact animals. Therefore, they concluded that the presence of an endogenous gonadotropin for the consistent effect of HCG in the process of spermiation is not absolutely a necessary factor. Chatterjee and Bhaduri (1972) found that hypophysectomy in toads (*B. melanostictus*).

caused severe degenerative changes in testicular structure and functioning associated with a regression in the secondary sex organs. Testosterone replacement was found to be absolutely inefficacious to reverse the detrimental effect of hypophysectomy on the gonads in the toad. However, testosterone was found to be successful to maintain the growth of secondary sex organs in the pituitary-ablated toads.

Guraya (1972) emphasized the role of amphibian sertoli cells as steroid secretor.

The cyclical variations in the testicular and adrenal histology has also been worked out by Thyagaraja and Sarkar (1971) in the toad. the regular sequence of storage and elaboration of the lipoidal material associated with cytoplasmic degranulation of the cortical cells appear to be correlated with the changes in the gonads.

HORMONAL CONTROL OF SPAWNING

Thyagaraja and Sarkar (1970) demonstrated the species specificity of the spawning pattern in frogs (*Rana cyanophlyctis*) and toads (*Bufo melanostictus*). They conclude that the oviduct regulates the spawning pattern by way of differential pattern of jelly secretion.

Both hypophysectomy and thyroidectomy in the frog have greater reducing effect on spawning response, showing thereby that thyroidectomy affects the ovaries directly by reducing their response to the ovulating agent in the pituitary homogenate (Sarkar and Rao, 1971a, b). Suvarnalatha and Sarkar (1972, 1973) demonstrated the mechanism of egg transport in the peritoneal cavity of the skipper frog, *Rana cyanophlyctis* and in the toad, *Bufo melanostictus.* By removing alternate oviducts and/or ovaries and inducing them to spawn, it was confirmed the occurrence of bilateral specificity in the ciliary tracts of frogs and toads.

SEX STEROIDAL EFFECTS ON METABOLISM

Kasinathan and Basu (1971a) studied the comparative effect of sex steroids on the muscle and serum electrolytes of *Rana hexadactyla.* In frogs treated with androgen and estrogen a significant decrease of tissue Na is noted in thigh muscle but the parallel level of increase in K is absent from the tissues. These authors (1971b, c) have also reported that testosterone administration has resulted in the increase of haemoglobin and RBC counts. Estrogens have resulted in the decrease of RBC and .haemoglobin and increase of WBC in frogs.

PISCINE

NEUROENDOCRINE CONTROL

Sundararaj and Viswanathan (1970) while studying normal cellular component and vasular system of hypothalamus of the catfish have found that the hypothalamic centres are under the inhibitory control of sex steroids and that nucleus lateralis tuberis is concerned with reproduction.

PHOTO-OVARIAN-RHYTHM

Sundararaj and his group have made extensive search for the study of endocrine control of reproduction in catfishes. It has been found that the *Heteropneustes fossilis* is a seasonal breeder and breeds during July-August in Delhi. It is also shown that reproductive cycle is related with photoperiodism. In order to investigate the mechanism of influence of photoperiodism in these animals they have also shown that ovarian recrudescence takes place in both intact and blind catfishes regardless of the photoperiodic regimen and concluded that eyes are not indispensable organs for such events and that reproductive cycle is regulated by an endogenous circannual rhythm even in the absence of photoperiodic stimulus. In addition to a circannual rhythm the catfish may have an endogenous circadian rhythm and when photoperiod is given at the proper phase of this rhythm, a response is obtained (Sundararaj and Sehgal, 1970a, b, c ; Sehgal and Sundararaj, 1970a, b).

HORMONAL CONTROL OF OVULATION

Sundararaj with his associates have demonstrated that fish pituitary produces only one gonadotropin, physiologically identical with the mammalian LH, causes oocyte maturation and spawning, and regulates entire process of oogenesis. Mammalian LH or LH-like preparation stimulates oognesis in catfish while mammalian FSH or FSH-like preparation is relatively inert. Fish gonadotropin injection in hypophysectomized gravid catfish or catfish with regressed ovaries or in gravid catfish, stimulated maturation, ovulation and spawning processes. Female pituitary is 2-3 times more potent than the male pituitary in inducing spawning in confinement. Compared to the fish pituitary, only ovine LH and HCG are reported to be potent ovulating hormone in catfish. This finding indicates the hypophyseal control of ovulation in the catfish and is similar to that in other vertebrates. They have also shown that only hydrocortisone and desoxycorticosterone prove to be the most effective ovulation inducing agents both *in vivo* and *in vitro* while ovine LH *in vitro* fails to do so although it is effective *in vivo* condition, indicating that the action of gonadotropin is mediated through corticosteroidogenesis in the interrenals and maturation of oocytes is caused mainly by stimulating *de novo* protein synthesis through translation of m RNA (Sundararaj and Goswami, 1971a, b ; Goswami and Sundararaj, 1971a, b ; Sundararaj *et al.*, 1972).

ADENOHYPOPHYSIAL REGULATION OF SPERMATOGENESIS

The male catfish exhibits a well defined annual cyclicity in reproduction. Spermatogenetic activity is highest during late preparatory and prespawning periods ; during the spawning period the seminiferous tubules are loaded with spermatozoa, and in the postspawning period the testis are regressed and quiscent. Hypophysectomy completely ceases spermatogenesis while administration of HCG or ovine LH or salmon pituitary gonadotropin in these animals, restore and maintain spermatogenesis. And the catfish testes are much more sensitive to salmon gonadotropin than to ovine LH and a single gonadotropin regulates all the reproductive activities in male catfish (Sundararaj and Anand, 1972).

HORMONAL INFLUENCE OF SEMINAL VESICLE

It is a pair of glandular structure, located at the base of the testes, follows cyclical activity coincident with testicular cycle, but it is very surprising to note that castration in the catfish remarkably increases the size of the seminal vesicle and becomes hypersecretory, accompanied by an increase in the number and activity of the gonadotropic cells alongwith an increased nuclear diameter of the interrenal cells. Thus, it indicates an existence of a pituitary-interrenal axis in the regulation of secretory activities of the seminal vesicle.

HISTOCHEMISTRY OF GONAD OF MARINE TELEOST

A histochemical investigation of the testicular interstitial tissue of marine teleost, *Belone belone* conducted by Upadhyay and Guraya (1971) revealed that the lobule boundary cells of these fish testes during breeding season show similar cytological and histochemical features of steroid secreting cells of the gonads of mammals and amphibians. Whereas the interlobulary interstitial cells do not develop these features of steroidogenic activities. Guraya (1972) by histochemical studies found that the origin and development of ovarian interstitial gland cells of dog fish *Scoliodon sorrakowah* closely resemble the corresponding cells in the ovaries of higher vertebratcs, including mammals.

LOWER CHORDATE

HISTOCHEMISTRY OF GONAD

Guraya (1972) carried out a histochemical study on the degenerating eggs and intestitial gland cells in ovaries of *Branchiostoma* (amphioxus) and reported that the degenerating mature ova of *Branchiostoma* ovary differ from the corpora atretica of vertebrate in that they do not possess follicle cells or their derivatives. The author suggested that these degenerating eggs do not appear to perform any endocrine function. Also the interstitial gland cells of thecal origin do not develop in amphioxus ovary as seen in vertebrates.

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COMPARATIVE ENDOCRINOLOGY OF VERTEBRATES

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Endocrinology has definitely advanced beyond the point where its objective is merely the better comprehension of hormonal mechanism in a single mammalian species (specially laboratory rats and mice). During recent years, the researches are being extended in other groups of vertebrates and we are now able to delineate the differences and perceive the alikeness in hormonal systems of mammals and other phylogenetic classes. This knowledge helps us considerably in dealing with the precise role of various endocrine glands in morphogenesis, in ecologic adaptation and also in the process of organic evolution. Further, the major practical contributions (actual and potential) of the vertebrate comparative endocrinology have also been emphasized by Bern (*Gen. Comp. Endocrinol.*, Suppl. 3 : 751-762, 1972). Progress of this specialized field in our subcontinent is marked by several national and international symposia held during recent years in New Delhi, Jaipur, Varanasi, Chandigarh and Aurangabad.

The present review covers the literature in comparative endocrinology of vertebrates published between 1970 and 1973. This review is by no means a complete record and due to obvious reasons quite a few important contributions may have been overlooked and omitted. The compilers are grateful to all vertebrate endocrinologists who have kindly responded by supplying material for inclusion in the present survey of literature.

HYPOTHALAMO-HYPOPHYSIAL SYSTEM

Recent studies carried out by Anandkumar and his associates have drawn attention to the possibility of specialized circumventricular and ependymal derivatives, occurring at certain well defined areas of the diencephalon in the rhesus monkey, together with the cerebrospinal fluid, participating in the neuro-endocrine regulation of sexual cycles (Anandkumar *et al.* 1973). The identification of these cellular and humoral pathways and the elucidation of their functional significance constitute a significant advance in the search for susceptible points in the neuro-endocrine chain of events which can be interfered with for purposes of regulating fertility. Vijayan and Sathyanesan

(1971) have studied the hypothalamo-hypophysial neurosecretory complex of the Indian palm squirrel *Funambulus pennanti* with the help of *in situ* staining techniques. The three-dimensional view of the bulk preparations has cleared many doubts as to the shape and topography of the supra-optic and the paraventricular nuclei and the tracts of the mammals in general.

Singh and Dominic (1970, 1973a) and Dominic and Singh (1971) demonstrated the presence of distinct anterior and posterior groups of portal vessels supplying respectively the cephalic and caudal lobes of the pars distalis in over forty avian species. It is postulated that this regional distribution of portal vessels provides anatomical basis for individual neuro-endocrine control of the median eminence over the cephalic and caudal lobes of the pars distalis.

Siddiqui and Chandrasekhar (1972) have found cyclic accumulation and depletion of Gomori positive materials in the ependyma and the third ventricular lumen and the phenomenon coinciding with the yearly ovarian cycles in the pigeon. A sudden depletion of the fuchsinophil material occurs prior to egg-laying. Dendrite-like extensions from glia cells laden with fuchsinophil granules are found to be extending into the lumen. A similar phenomenon has been observed in duckling too. Profuse vascularization of the sub-ependyma has been discerned in both during the secretory phase. These authors previously (1970) have discerned functional differentiation in neurons of supra-optic (SON) and paraventricular (PVN) groups of neurons in the pigeon and continuous light enhancing the accumulation of Gomori positive material in the SON and lack of light increasing it in the PVN. Light enhances and darkness depresses thyroid functioning. The gonads shows continuous proliferation in the former and degeneration in the latter. Further, thyroidectomy brings about atrophy of the neurons in the SON and the PVN and the gonads. Authors have recorded an existence of 'hypothalamo-hypophysial-thyroid-gonadal axis' in pigeons (Chandrasekhar and Siddiqui, 1971).

Osmotic stress following dehydration causes enlargement of supra-optic nucleus (SON) of the hypothalamus followed by depletion of neurosecretory materials (NSM) in the neurohypophysis, Water deprivation of moderate duration releases more NSM from the posterior median eminence (PME) than the anterior median eminence (AME). A severe dehydration stress (of 118 days), however, brings about near-complete exhaustion of NSM from both the AME and the PME ; but NSM is not completely depleted from the neurohypophysis (Ghosh and Ghosh 1972). It seems that gross absence of pars intermedia in birds (an avian characteristic) has no deleterious effect on the survivality during prolonged water deprivation (*cf* Legait and Rouse, 961, *C.R.Soc.Biol.*, Paris 155 : 379-381).

Kulshreshtha and Dominic (1971a, b, 1972a, b, c) have reported that in the musk shrew it is the paraventricular nucleus (PVN) and not the supraoptic nucleus (SON) which is primarily affected by hyperosmotic stress. They have suggested that the PVN may be the more important site of the production of the antidiuretic hormone (ADH) in the musk shrew. The hypertonic saline-induced changes in the HNS of the musk shrew was prevented by administration of reserpine (Kulshreshtha and Dominic, 1971a), chlorpromazine (Kulshreshtha and Dominic, 1971b), ethanol (Kulshreshtha and Dominic 1972a), chloral hydrate (Kulshreshtha and Dominic, 1972b) and ACTH (Kulshreshtha and Dominic, 1972c).

Radiothyroidectomy and neomercazole cause degranulation and vacuolization of nucleus preopticus (NPO) cells in *Bufo andersonii* (Dixit and Ramaswamy, 1971). It also shows a depletion of AF-positive material in the median eminence and pars nervosa, whereas thyroxine treatment enhances the activity of the NPO cells in a radiothyroidectomized toads.

The effects of thyroid inhibitor have been studied on the hypothalamo-hypophysial neurosecretory system of a freshwater teleost, *Clarias batrachus* by Dixit (1970d). Methyl thiouracil (MTU)/thiourea causes degranulation and vacuolization of cytoplasm in the nueleus preopticus. The cell nuclei shows a significant decrease in nuclear dimensions. Depletion of NSM has been noticed in the hypothalamo-hypophysial neurosecretory system after MTU administration for a period of 10 days. The possibility of a hypothalamic control of pituitary gland has been suggested.

Spaying causes an increased activity of gonadotrops, nucleus preopticus and nucleus lateralis tuberis in *Clarias*, Estrogen releases neurosecretory material of the neurohypophysis into the circulation. It also causes an increase in nuclear size and degranulation in the cells of nucleus preopticus, nucleus leteralis tuberis and gonadotrops in a ovariectomized *Clarias*. It shows that estrogen sensitive centres are present within the hypothalamus which regulate the activities of pituitary gonadotrops (Dixit, 1970a). Chandrasekhar and Khosa (1972) have found exogenous estrogen and progesterone enhancing accumulation of fuchsinophil material in pre-optic nucleus in *Clarias batrachus* and complete absence of ovarian hormones causing depletion. Further, progesterone alone brings about abnormal enlargement of neurons. Two to five days administration of metopirone in *Clarias* brings about specific changes in the Pb-Htx cells. These cells possibly secrete ACTH and are located on the border of the neurohypophysis. Depletion of neurosecretory material (NSM) is noticed in the cells of nucleus preopticus (NPO), nucleus lateralis tuberis(NLT), hypothalamo-hypophyseal tract and neurohypophysis. Longer treatment (8-15 days) enhances the thyrotropic activity of the pars distalis (Dixit, 1970b).

Sathyanesan and Shamim Haider (1970) have demonstrated post-hypophysectomy regeneration and irregular growth of the neurosecretory axons. These authors (1971a) and Sathyanesan (1971a) have reported a hypothalamo-hypophysial portal circulation of tetrapodan type in the teleosts *Heteropneustes fossilis* and *Clarias batrachus.* Such a portal system was thought to be absent in teleosts by earlier investigators. Sathyanesan (1971b) and Sathyanesan and Shamim Haider (1971b) while studying the histochemistry of the hypothalamus and neurohypophysis of some teleosts, have suggested that the pituicytes might be involved in a feedback mechanism involving the secretory activity of the neurosecretory neurons.

Shamim Haider and Sathyanesan (1972a, b), Sathyanesan and Jose (1973) have studied the architectural pattern of the hypothalamo-hypophysial complex of a number of teleostean species adopting *in situ* staining techniques. This study reveals the presence of a variety of patterns in the structure of the nuclei and the course of tracts, Such variations are of great importance in assessing the evolution of this important system. Belsare and others (1970) have studied the effects of hypophysectomy on the hypothalamo-hypophysial neurosecretory system and observed that hypophysectomy resulted in the increase of AF-positive material in the neurons of nucleus preopticus shortly after the operation, but later on the material started to deplete. The AF-positive material at the cut end, however, is accumulated. It is observed that the NSM of nucleus preopticus is transported by the axonal route whereas that of the NLT is by axonal as well as by the ependymovascular pathways.

CAUDAL NEUROSECRETION

The effect of ovariectomy and administration of sex steroids has been studied in the teleost, *Clarias batrachus* for its secretory activity in the caudal neurosecretory cells. Spaying causes an enlargement of the caudal neurosecretory cells. Estrogen treated ovariectomized *Clarias* shows granulation of their cytoplasm (Dixit, 1971).

CYTOLOGY OF THE ADENOHYPOPHYSIS

Naik and Dominic (1972) described in detail the cytology of the adenohypophysis of the musk shrew, the TSH, FSH, ICSH (LH), LTH (prolactin), STH and ACTH cells were identified on the basis of their morphology, topography, tinctorial pattern and response to be various experimental stimuli. In contrast to the situation prevailing in teleosts and certain mammals, in the musk shrew the LH cells have been demonstrated to be lead-haematoxylin positive (Naik and Dominic, 1973),

ADRENAL MEDULLA

Ghosh in an exhaustive review (1973) has summed up the recent works on the histophysiology of the avian adrenal medulla, particularly conducted in his own laboratory. The findings of Ghosh and his associates emphasize the dynamic behaviour of the avian adrenaline and noradrenaline. Extreme variation of relative concentration of these two hormones in medulla is a unique feature of birds amongst other vertebrates. In birds, noradrenaline appears to be an equally effective blood sugar enhancing hormone compared to the adrenaline. A probable mechanism of the avian noradrenaline action in hyperglycemic response has also been proposed by Ghosh (1973). An almost equal effectiveness of both adrenaline and noradrenaline as pressor hormones has been recorded in the avian group.

Sitaraman and Ghosh's (1973) study on biosynthesis reveals a hitherto unknown fact that ascorbic acid (besides corticoids) plays a positive role in methylation of avian (pigeon) noradrenaline. It has been found in pigeons that resynthesis of these catecholamines begins 48 hours after complete release by reserpine treatment and the normal level is reached within 15 days and adrenaline is synthesized at a faster level than noradrenaline (Ghosh and Ghosh, 1972). In order to ascertain the basic cytochemical substances present in the adrenal medulla of birds it has been found that Myna adrenal medulla comprised mainly of adrenaline secreting cells and contains large amount of acid phosphatase, acetylachclinesterase, lipase, acetalphosphatides, ascorbic acid and weakly acidic sulfomucins (see Ghosh, 1973). Narasimham and Kamat (1970a) have reported a simple method to differentiate adrenal medullary (chromaffin cells) from cortical (nonchromaffin) cells, particularly in lower vertebrates, amphibians, reptiles and birds, using haematoxylin. It is suggested that the intense staining of medullary (chromaffin) cells, is due to protein basophilia of these cells, An effort has been made by these authors to give a comparative and comprehensive report on the distribution of chromaffin and nonchromaffin cells in different vertebrates (Narasimham and Kamat, 1970b). Inhibitory-sensitive inhibitory-resistant and substrate specific phosphatases (alkaline phosphatase, acid phosphatase and adenosine triphosphatase) have an interesting distribution in the adrenal medullary cells (Narasimham and Kamat, 1970c). The adrenal chromaffin cells of some vertebrates have been analysed by various histochemical methods for the presence of phospholipids and mucopolysaccharides (Narasimham and Kamat, 1970d, e ; 1971).

Findings on the relationship between the medullary hormones and stressful stimuli (heat and cold stress, population pressure and emotional stress) have been reported by Ghosh in a series of studies (*see* Ghosh, 1973). It is a common experience for the poultrymen that during hot summer days poultry birds die in large numbers. Injection of noradrenaline has been found to afford 100% survivality in pigeons exposed to 50°C for 3½ hours. Normally more than 50% of pigeon die in this condition. This information has a definite implication in the poultry husbandry. Banerji and Ghosh (1973a) has also noted adrenaline depletion in a murrel subjected to heat stress. Lahiri (1973) has studied influence of age and climatological variation on the adrenomedullary amines and blood sugar level in pigeons.

Banerji (1973) has made a comparative histological survey of interrenal and chromaffin tissues of ten teleost fishes, It has been found that reserpine treatment can exhaust adrenaline from the interrenal glands in teleosts as in birds (Banerji and Ghosh, 1972). Adrenaline treatment caused transient hyperglycemia in fishes in both starved and unstarved conditions while noradrenaline failed to do so (Banerji and Ghosh, 1973b).

Prolonged fighting in the bandicoot rats stimulates both synthesis and release of adrenaline and noradrenaline from the adrenal medulla (Ghosh and Maiti, 1972, 1973).

ADRENAL CORTEX

The adrenal cortex of some birds seems to have a mammal-like histologi cal zonation since there is a difference between the subcapsular and central cords. It is recognisable partially in pigeon, moderately in duck and very sharply in flamingo while no such zonal specificity in chick is evident from the study of twentytwo species of birds belonging to seventeen orders (Bhattacharyya *et al.*, 1972a). But physiologically zonation in the interrenal gland has been established only in some birds (Bhattacharyya and Ghosh, 1972). Chemical stress and amphenone treatment plus stress stimulate adrenocortical activity in pigeons (Bhattacharyya *et al.*, 1972b). Epsilon cells (alleged to be ACTH secretor) of the pars distalis are stimulated following unilateral adrenalectomy, formalin and dexamethasone treatments in pigeons and suggested to have definite correlation between adrenocortical stimulation/inhibition and ACTH production (Bhattacharyya, 1972).

Physiological pathways for stimulating cortisol release, in the absence of the pituitary, present an unresolved problem in teleosts. Srivastava and Meier (1972) made the discovery of a daily variation in concentration of cortisol in plasma, which is synchronized by a 12-hour daily photoperiod in intact as well as in hypophysectomized killfish, *Fundulus grandis*. Apparently, the daily rhythm in concentration of the adrenal steroid does not depend on a driving rhythm of pituitary adrenocorticotropic hormone (ACTH). Histophysiology of interrenal gland in normal, hypophysectomized, ACTH and SU-4885 (metopirone) treated teleost, *Clarias batrachus* has been studied by Dixit (1970c). Hypophysectomy brings about a marked atrophy of the interrenal tissue, mammalian ACTH restores the atrophied cells. Metopirone (SU-4885) has no effect on the interrenal tissue in a hypophysectomized fish, whereas in normal animals, metopirone (SU-4885) activates the interrenal cells in a similar manner to mammalian ACTH. Cortisone acetate causes interrenal cell atrophy. Belsare (1973a) has studied the histogenesis of the interrenal corpuscles, the chromaffin tissue and the corpuscles of Stannius in *Channa punctatus*. The interrenal corpuscles arise from coelomic epithelium whereas the chromaffin cells originate from sympathetoblasts. They are closely associated right from early stages of their development. Since the interrenal corpuscles do not stretch posteriorly, they remain in the region of pronephros. The origin of corpuscles of Stannius is from the mesonephric tubules. The author (1973) has also studied the histomorphology of the corpuscles of Stannius in ten species of teleosts,

THYROID

Dev and Srivastava (1971a, b, c,) have studied the response of thyroid gland to different doses of P^{32} in the mouse. Lower doses cause discernible damage not earlier than 8 to 10 days after P^{32} treatment and only small follicles are affected. P^{32} at a higher dose shows desquamation and distortion of epithelium 30 days after administration. The 60-day thyroids (P^{32} treated) reveals recovery over the 30-day treated ones. With a still higher dose, gradual loss of colloid from the follicles is evident and colloid-like meterial is demonstrated in the lumen of the blood vessels. Dixit and Lohiya (1973) have investigated the goitrogenic action of metopirone in bat (*Rhinopoma* and *Taphozous*) and desert gerbil. The I^{131} content of the thyroid gland is significantly higher in the metopirone treated groups than in the controls. This is interpreted as being the result of a decrease in the rate of discharge of thyroid hormone I^{131} conversion rate. The evidence discussed are quite conclusive that SU-4885 acts on thyroid gland function directly as well as by influencing pituitary thyrotrophic activity in enhancing I^{131} uptake. Lahiri and Banerji (1970) have noted thyroidal hyperactivity and medullary noradrenaline depletion in the pigeons exposed to high altitudes.

Vijayan and Sathyanesan (1971) have reported the appearance of ectopic thyroid in the thymus of radiothyroidectomised *Funumbulus pennanti.* Those ectopic cells start trapping iodine only after the destruction of their normal thyroid with radioiodine. Belsare (1971) while studying the thyroid cycle in *Channa punctatus* has observed that it does not show any direct response to change in temperature of water. The thyroid activity in *C. punctatus* has a closer relationship with the breeding activity than with the temperature of the habitat. Srivastava and Sathyanesan (1971a, b,) have reported the heterotopic renal thyroid of *Puntius sophore* and *Amphipnous cuchia* to be more active than the pharyngeal on the basis of their histology and capacity to bind more of radioactive iodine. Shamim Haider and Sathyanesan (1973) have reported the presence of a triiodothyronine sensitive area in the lateral hypothalamus of the teleost *Clarias batrachus* with the help of autoradiographic studies. It has been postulated that this specific area may be the site of T_3 feedback. Pandey (1973) has experimentally identified the thyrotrops and gonadotrops in the hypophysis of *Rasbora daniconius.* It has been found that thyroidectomy results with the interference of pituitary - thyroid axis and consequently brings about the hyperfunctioning of the TSH cells. The proximal pars distalis of the hypophysis possesses these cells which eventually show vacuolization. On the other hand thyroxine treatment results in the hypoactivity of cyanophils. The cyanophils are of two morphologic varieties one is columnar elongated type and other polygonal and oval type. The latter type shows the vacuolization and granulation when experimentally induced with goitrogens or thyroxine respectively, while the other variety shows a parallel activity with the physiology of gonads.

PANCREAS

In order to understand the mechanism of glycemic response in two reserpinized avian species, a thorough investigation has been carried out by Guha and Ghosh (1970) on the cytology of the endocrine pancreas. In pigeons only a slight degranulation of beta cells is noticeable after reserpine treatment, while in crows the alpha cells show an enhanced granular content and nuclear hypertrophy. Since no major alterations is found in the cytophysiology of pancreas after reserpine administration and existing reports show significant adrenomedullary changes, it is presumed that in these two species the adrenal medulla plays a more important role in maintaining the blood sugar homeostasis than the endocrine pancreas. Kalyanam and Gurumani (1971) have described the endocrine pancreatic cytology of a migratory avian species, *Tringa glareola.* In this species the islets of Langerhans are distributed throughout the pancreas, but they are concentrated more tn the splenic part than in other regions. As in other birds three types of islets are seen, the dark islets containing A- and D-cells, the light islets with B- and sometimes, D-cells and the mixed islets having all the three types of cells.

ENDOCRINE CONTROL OF UROPYGIAL AND SALIVARY[1] GLANDS

Uropygial gland - a sebaceous gland homologue, has practically no discernible difference in histomorphological structure or in cytochemical entities in ten avian species studied, while only in *Coturnix coturnix;* a definite zonation between peripheral and central alveoli is marked (Bhattacharyya, 1972). Cytochemically like sebaceous glands, this gland in pigeon, contains mainly esterase, lipase, cholinesterase, succinic dehydrogenase and acid phosphatase and are someway associated with the synthesis of lipids (Bhattacharyya and Ghosh, 1971). Uropygial gland is maintained by androgen (Maiti and Ghosh, 1972). Estrogen is not required for its normal function (Maiti, 1971). Progesterone alone cannot influence this gland (Maiti, 1972). Scurvy causes regression of the uropygial gland activity in bulbul probably by inhibiting androgen supply (Maiti and Ghosh, 1972).

Mandal and others (1971) have shown that the pigeons have eleven salivary glands i. e., maxillary, palatine (masked), sphenopterygoid. crico-arytenoid, posterior lingual, mandibular and anterior lingual (masked). All are paired except the palatine and both the lingual glands. On the basis of cell size and nature of secretion two types of glands are discernible. Type A (maxillary and anterior lingual) possesses short columnar cells giving a characteristic serous appearance while rest are type B with tall columnar mucogenic cells. Castration can regress the function of the salivary gland complex.

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TAXONOMY OF INVERTEBRATES (EXCLUDING INSECTS)

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PROTOZOA

Rao (1970) has listed 14 genera and 37 species of Foraminifera in the Gulf of Cambay, Gujarat. Taxonomic notes and distribution across the world have been given.

COELENTERATA

A new species of sea-anemone designated as *Cribrinopsis robertii* was described by Parulekar (1971a) from Maharashtra and Goa coasts. This is the third species assigned to the genus, and the first species recorded from tropical waters, the other two congeneric species being reported from low arctic and Alaska.

POLYCHAETA

A member of species of Polychaeta from the intertidal region of 15 localities in Maharashtra and Goa have also been listed by Parulekar (1971b). They comprise 54 species belonging to 36 genera and 16 families. Brief taxonomic notes together with notes on the range of distribution have been given.

SIPUNCULIDA

Four species of *Phascolosoma* Leuckart, which include two new species, and one species of *Phascolopsis* Fisher, have been listed and described by Johnson (1971). Only 13 species of Sipunculida are so far known from the Indian waters.

ECHIUROIDEA

Species of the genus *Ochetostoma* in the collection of the Zoological Survey of India, Calcutta, have been studied by Dattagupta and Menon (1971).

Anatomical notes on *O. erythrogrammon* (Leuckart and Ruppell), *O. kempi* (Prasad), *O. australiense* Edmonds, and *O. bombayensis* (Prasad) is given, which should facilitate recognizing the species. A brief key to the species of the genus is also included.

CRUSTACEA

Gopala-Menon (1972) studied the larval development of *Heterocarpus* (Caridea) from material obtained from the International Indian Ocean Expedition. He points out that marine crustacean larvae owing to long series of larval stages are difficult to relate to their respective adults. Larval species *Atlantocaris gigas* Ortmann is shown to be the larva of *Heterocarpus ensifer* A. Milne-Edwards. Adult *Procletes biangulatus* Bate and *Heterocarpus* (*Heterocarpoides*) *levicarina* (Bata) are synonymous. Smith (1884) pointed out pandalid characters of the genus *Heterocarpus*, subsequent authors placed *Heterocarpus* under Pandalidae. Thompson (1967, not listed) recommended creation of a new superfamily Heterocarpodoidea to include the families Heterocarpodidae, Rhynchocinetidae and Campylonotidae. Larval characters of *Heterocarpus* (including *Procletes*) are consistent with its inclusion in Pandalidae.

Larvae and adults of *Thalassocaris lucida* (Dana), *T. crinita* (Dana), and *T. obscura* sp.n. have been described by Gopala-Menon and Williamson (1971). *T. crinita* is a shallow-water species with a wide distribution in the Indian Ocean. *T. lucida* is most common in the eastern Indian Ocean, while *T. obscura* is most common in the Arabian Sea. Larval evidence on the taxonomic affinities of *Thalassocaris* favours the separation of the genus from Pandalidae and rehabilitation in Thalassocaridae.

Nayar (1971) has listed 17 species of Cladocera (Crustacea) from different localities of Rajasthan. Texonomic notes and distribution of the species in Rajasthan have been incorporated. The only species of Cladocera known from Rajasthan was *Latona tiwari* described by Biswas (1964, not listed).

Silas (1971) has given a list of all new taxa described by the late Dr. R. B. S. Sewell, including those belonging to non-copepode groups which facilitate easy reference. Correct paginations of the original descriptions, details of illustrations, number of type specimens, sex on which the description is based and type localities are included. A bibliography of Sewell's fifty years' work on the aquatic fauna of India and adjacent countries and the seas around India is also given at the end of the paper.

The inclusion of Thalassinoidea in Anomura has been stressed by Sankelli (1970-1971) although there have been contradictory opinions. Indian

Thalassinoidea reported earlier are mainly from deep sea. From the intertidal area of Maharashtra, four species belonging to three families have been listed and described. Of these, two are new to science. Keys to the families and sub-families have been incorporated.

Sebastian (1970) has described *Branchiophryxus koehleri* and *Heterophryxus appendiculatus* (Epicaridea, Dajidae), parasitic on Indian mysids. Description of different stages of growth should facilitate better understanding of the species.

Ten species of harpacticoids copepod from the estuary of Vellar river (Porto Novo) have been listed and described by wells (1971). Of these, *Stenhelia (Delavalia) madrasensis, Pseudostenhelia secunda* and *Apodopsyllus camptus* are new to science. Intraspecific variation has been prominent in some, namely, *Nannopus palustris* Brady and the species of *Limnocletodes.*

ARACHNIDA

The scorpion genus *Charnus*, according to Sreenivas Reddy (1970), is closest to the family Buthidae. and the affinities are on the basis of cheliceral dentition, trichobothrial distribution, and chitinous reinforcement of lung lamellae. In 1917, Birula placed the genus under the family Vijovidae, and Sreenivasa Reddy's reasoning for its new status was the presence of pentagonal sternum ; but a pentagonal sternum is not a characteristic feature Vijovidae alone.

Stahnke (1972) had discussed the nomenclatural status of *Heterometrus* and *Palamnaeus* (Scorpionidae). Opinion vary with regard to the genus *Heterometrus* and its type species. The genus *Haterometrus*, originally introduced as a subgenus of *Buthus* (Ehrenberg and Hemprich, 1828, not listed) represented by *Buthus* (*Heterometrus*) *plamatus* from Africa and *Buthus* (*Heterometrus*) *spinifer* from India, was raised to generic level by Peters (1861, not listed) Thorell (1876, not listed) erected the genus *Palamnaeus* and declared *Scorpio maurus* Linnaeus, 1758 as synonymous with *B. palmatus*. Stahnke (1972) followed Karsch's reasoning and applied the generic name to the remaining species *B.* (*H.*) *spinifer* and chose for it *Buthus* (*Heterometrus*) *spinifer* Ehrenberg and Hemprich as the type species (Code 69B, Choice by elimination). *Heterometrus* and *Palamnaeus* thus appear synonymous.

Tikader (1970-1972) continued with his catalogue and bibliography of the Indian spider fauna. In three instalments published during the period under review, he has listed 207 species under about 67 genera and 16 families. As in the earlier parts, the first reference of each species, its distribution and the location of its type have been given.

MOLLUSCA

Smythe and Phillips (1972) have listed 107 species under 64 genera and 31 families of marine shells from Maldive Islands. Bivalves though common and abundant in the islands have not been adequately represented in Mrs. P. Phillip's collection upon which the paper is written.

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STUDIES ON INVERTEBRATE (EXCLUDING TAXONOMY)

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COELENTERATA

Mookerjee and Mitra (1971) have recorded the morphogenetic abnormalities like crumpyness of body contour, appearance of extra basal discs, low rate of bud production and absence of gland cells in radiated *Hydra.* The period of persistence of abnormality varied in length extending for more than two years but was regulated eventually.

HELMINTHES

Gupta and Walia (1970) dealt with the morphology, anatomy and histology of the amphistomid trematode *Gastrodiscus aegypticus.* The anterior portion of the worm is cylindrical, the posterior flattened. Size 5.9 x 3.2 mm. Ventral surface lined with papillae containing lymph vessels. Acetabulum and body length ratio 1 : 5.4. Dorsal exterior circular muscles 20-30 in number; ventral interior circular muscles 21-28. Mouth terminal, pharynx provided with an anterior sphincter, musculature of pharyngeal bulb and sacs less developed. Instestinal caeca almost straight. The dumbbell-shaped brain gives off three pairs of nerves anteriorly and posteriorly. No transverse communication between the longitudinal exeretory canals. The excretory pore in postvesicular and behind the opening of Laurer's canal. Lymphatic system in the form of a network. Testes lobed. Ovary posterior to the testis and lies on the left side. Genital atrium without genital sphincter.

The morphology, anatomy and histology of the cestode *Cotugnia meggitti* from *Columba livia* of Chandigarh are described by Gupta and Grewal (1971). The haploid chromosome number in the species is 10.

ANNELIDA

Bhatia (1972) reinvestigated segmentation in the Indian Leech *Hirudinaria,* and Medicinal Leech, *Hirudo.* In ascertaining a true somite only the nerve ganglion and the segmental receptor organs are considered. The receptors are present in the first annulus of all segments including incomplete segments at the two extremities with nerve ganglion in the first annulus of the segment. The clitellum occupies three natural segments, IX, X and XI. Septa at the level of each nerve ganglion in embryos is considered as a conclusive evidence.

Kumar (1972) has studied the functional morphology of the setal protractors of the earthworm, *Pheretima posthuma.* The setal protractors radiate outwards from the base of the setal follicle at various angles with the follicle. They are divisible into two groups, adfollicular and perifollicular, pass through the longitudinal and circular muscle layers and are distally attached to the basement membrane of the epithelium. The adfollicular strands function exclusively as protractors, while the perifollicular ones keep the protruded seta straight against the forces of push and pull during locomotion. The mesial segmental nerve of each side arises together with the posterior segmental nerve with which it is intercommunicated, and innervates the protractor strands. The longitudinal muscle layer is innervated by the posterior segmental nerve. The relation between the contraction of the longitudinal muscle layer and the setal protractors of a segment is probably nerve mediated.

MOLLUSCA

Nagabhushanam (1970) has found that the general anatomy of the central nervous system of the bivalve *Diplothyra smithii* is similar to that of *Marteria striata* in size and staining reactions. The types of neurosecetory cells, type I pyriform cells and type II oval cells are present.

The digestive gland of the land-snail *Euplecta indica* consists of a number of blind tubules separated by interlobular connective tissue according to Kanwar and Harminder (1970). Three types of cells, digestive-cum-excretory, calcic and undifferentiated cells are reported from the gland.

Patil (1970) has studied the nervous system in the bivalve *Lamellidens consobrinus.* The cerebral ganglia are separate but the paired visceral and pedal are fused to form butterfly - and H-shaped bodies, respectively. A circumpallial plexus is present. The osphradium is ventral to the visceral ganglia and the statocyst, usually in association with the pedal ganglia, is degenerated.

In their studies on the reproductive system and gonadal activities in the bivalve *Lamellidens marginalis,* Ghosh and Ghosh (1972) have found that both the testes and ovaries are large and coalesce at the middle to form a voluminous mass embedded in the digestive gland. Both the ovary and the testis are made up of large number of oval follicles bound together by connective tissue. Gonoducts are separate. Spermatogenesis takes place throughout the year. A periodicity is present in the female gonad, which is divisible into three phases, a quiescent, a preparatory and an active phase. Nurse cells take active part in the contribution of yolk to maturing ova. Three to four ova are commonly found in a follicle.

ECHINODERMATA

Bai (1971) induced eviscerntion in *Holuthria cabra* by injecting distilled water into the coelom. Regeneration of the alimentary canal and the haemal system started from mesentery and that of the respiratory tree from the ruptured end of its main stem. The author concludes that the phenomenon of evisceration is neither spontaneous nor seasonal.

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INSECT TAXONOMY

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COLLEMBOLA

Mitra (1973), while revising the genus *Salina* Macgillivray, 1894 (Family Entomobryidae), recognizes 10 species and one subspecies, which are differentiated into two groups, namely, *Indica* group and *Celebensis* group. The former group contains only three species, namely, *S. indica* (Imms), *S. bengalensis* Mitra and *S. biformis* Mitra. The remaining species belong to the *Celebensis* group.

ODONATA

Kumar (1973) gives a taxonomic description of the immature stages of 24 species of Odonata (Zygoptera 12, Anisoptera 14) from the Dehra Dun valley in the foothills of Western Himalaya. This marks the first concerted effort to carry out a systematic study of the immature stages of dragonflies and damselflies in India. The identification is based on a combination of morphological characters of the final instar larvae. These characters are useful for the formulation of dichotomous keys. Larvae of 10 families, viz., Gomphidae, Cordulegasteridae, Corduliidae, Libellulidae, Protoneuridae, Platycnemididae, Coenagriidae, Chlorocyphidae, Epallagidae and Agriidae belonging to 24 genera, with brief notes on their biology are discussed. Observations on the life histories of some species, treated as "provisional assumptions", alongwith notes on seasonal succession form another useful part of the studies.

HOMOPTERA

Ghosh (1973), on the basis of re-examination of the Aphididae species suggests new synonymies and new combinations.

Ghosh and Verma (1973) describe *Himalayaphis* as a new genus with *H. anemones* as the type species from the host-plant *Anemone* sp.

Lambers (1973), describes a new genus *Schizoneurella* with *S. indica* as type species, the host alternating between *Ulmus villosa* and *Malus pumila* from

India and Pakistan, besides describing three new species of aphids from the Indian subcontinent.

Ramakrishna and Menon's (1973) contribution on the Indian Typhlocybinae (Homoptera : Cicadellidae), places the taxonomy of this group on a sound footing. In the segregation of different genera of the Tribe Erythroneurini the importance of the characters of genitalia hitherto ingored by workers, has been emphasized. Fourteen new species belonging to seven new genera viz., *Spatulostlpus, Ratburella, Indianella, Cassianura, Zyginopsis, Kodaikanalia* and *Erythroneuropsis* have been described from India.

PSOCOPTERA

New (1973a) added to our information of psocoptera from Indian subcontinent by describing four new species belonging to the genera *Scopsis, Caecilius, Trichodenotecnum* and *Myopsocus,* from Nepal. Altogether 25 species are now known from Nepal. Many of these species are also known from West Bengal. New (1973b) further describes 6 new species from Thailand and records eight families for the first time from that part of the Oriental region. Two genera *Epipsocopis* and *Psudoseopis* have been recorded for the first time from the Oriental region.

THYSANOPTERA

Ananthakrishnan (1973) proposes *Projectothrips bhattii* as new name for *P. pandani* which he originally described in 1953. He also proposes *Varshneyia* for the genus *Takahashia* Ananthakrishnan (1970) which is preoccupied by the coccid genus *Takahashia* Cockerell (1896).

Bhatti (1973a) redescribes the genus *Projectothrips moulton* (Thysanoptera : Thripidae) on the basis of the authentic material of five species and includes seven species in this genus from India, Indonesia, Taiwan and Hawaii Islands.

Bhatti (1973b) gives a preliminary revision of *Sericothrips* Haliday, sensu lat., and related genera (Thysanoptera : Thripidae). He further presents a new concept of the Tribe Sericothripini and includes eight genera in it. He suggests that the subtribe Scirtothripina be placed in tribe Tripini. Under the redefined *Sericothripini,* he describes four new genera viz., *Corcithripes, Elbuthripes, Faureana* and *Kazinothripes* out of the eight genera recognized.

A key to the genera, on the basis of morphological characters not hitherto used, is also provided.

PHTHIRAPTERA

Tandon (1973) while giving a detailed account of the genus *Esthiopterum* (Phthiraptera : Ischnocera), parasitic on Cranes, describes *Esthiopterum elbeli* and *E. indicum* as new species from India with the type-hosts *Anthropoides virgo* (L.) and *Grus antigone antigone* (L.), respectively.

COLEOPTERA

Ohira and Becker (1973), describe five new species of Elateridae (Coleoptera) from Nepal. In addition, three already known species have been recorded from the area. The extension of the range of distribution of known species from Vietnam and North Burma to Nepal is of great zoogeographical importance.

HYMENOPTERA

Joseph, Narendran and Roy (1973) report descriptions of 21 new species, 7 new subspecies, and revisions of 43 known species including redescription of 16 little known species of *Brachymeria* (Hymenoptera : Chalcididae). A key to the Oriental species known so far is given.

Many species are primary parasites of Orthoptera (Acrididae), many families of Lepidoptera, few families of Homoptera and Diptera. The Black-headed Caterpillar pest of Coconut in Kerala, *Nephantis serinopa* is parasitised by six species of *Brachymeria* instead of only a single species *B. nephantidis* as hitherto believed. This information is of great value in many future control programmes against the caterpillar. The value of the work would have been enhanced if the authors had provided a host-parasite index also.

Mani, Dubey, Kaul and Saraswat (1973) carried out taxonomic studies on the parasitic Hymenoptera from India. They described fiftyfive species new to science and redescribed eight khown species covering the families Chalcididae, Perilampidae, Cleonymidae, Eupelmidae, Encyrtidae and Mymaroidea. The genera *Epitelia* Kirby, *Arretocera* Kirby, *Trichoxenia* Kirby, *Euperilampoides* Girault, *Chalcedectus* Walker, *Lycisa* Spinola, *Macromesus* Walker, *Solenura* Westwood, *Thaumasura* Westwood, *Calocerinus* Howard, *Zapachia* Forster, *Callipteroma* Motschulsky, *Coelopencyrtus* Timberlake, *Ooctonus* Haliday, *Gonatocerus* Nees, *Anaphes* Haliday, *Anagrus* Haliday, *Mymarilla* Westwood and *Polymema* Haliday have been recorded for the first time from India. This work which is still in progress marks a major land mark in the study of parasitic Hymenoptera in the country.

Nagaraja's (1973) studies on the systematics of *Trichogramma* (Family Trichogrammatidae) is of considerable importance for the biological control programmes in India. He describes six new species, bringing the number of species known from this country to twelve, and provides a dichotomous key for their identification. He conducted crossing experiments between closely resembling species and discovered the existence of sibling species in the *Trichogramma* population. Finally, he concludes that the reproductive isolation, in nearly alike species, is evidently due to sympatric speciation.

Sharma (1973), added two new species from India, belonging to the *Carbonarius* group of the genus *Apanteles* (Family Braconidae), to the already known three species of the group from Philippines, Europe and England. Hosts of both of these species belong to Lepidoptera. Sharma further describes (loc. cit.) one new species of the *Formosus* group from India, and also records its host.

Subba Rao (1973) describes four new species of the family Pteromalidae, two of these being from Africa, one from Indonesia and one from India. The two latter species belong to *Mokerzeckia* genus, hitherto known by only two species from Europe. The new species of *Mokerzeckia* are both primary and secondary parasites in habits.

DIPTERA

Alexander (1973) describes eight new species of Tipulidae (Diptera), from Sikkim and Assam, under four genera viz., *Antocha, Gonomyia, Trentepohlia* and *Erioptera.*

Cherian (1973) enhanced our knowledge of Cholropidae (Diptera) by describing seven new species, of the predominantly Oriental genus *Rhodesiella* Adams, thus raising the total number of the species of this genus from India to eleven. He also provides key to the identification of all the eleven species.

Dutta (1973) described six new species of the genus *Simulium* Latreille (Family Simuliidae), belonging to two subgenera viz., *Eusimulium* (four species) and *Gomphostilbia* (two species), from eastern Himalayan region.

Joseph (1973) gives detailed redescriptions of eight species of *Nephrotoma* Meigen and four species of *Ctenophora* Meigen. These species were originally described by Brunetti under *Pachyrhina* Macquart and *Pselliophora* Osten-Sacken (Diptera : Tipulidae), respectively. Most of these species are from Assam and Eastern Himalayas.

Reddy and Krishnamurthy (1973) and Sajjan and Krishnamurty (1973) described three new species of *Drosophila* (Family Drosophilidae) from south India.

Singh and Ipe (1973) made significant contribution to the systematics of Indian Agromyzidae, by bringing together under a single cover all the information on the systematics of Agromyzidae from India, as at present known. They also present freshly formulated dichotomous keys for the identification of the Indian taxa, for both the adult forms and the immature stages. The family Agromyzidae (Diptera), popularly known as "leaf-miners", which so far has suffered a complete neglect at the hands of the Indian entomologists, is expected to attract the attention of the insect taxonomists by this publication.

Altogether over one hundred and thirty species, belonging to seventeen genera are dealt with, of which thirty three are new to science. The genera treated are *Agromyza* Fallen, *Japanagromyza* Sasakawa, *Melanagromyza* Hendel, *Ophiomyia* Braschnikov. *Phytobia* Lioy, *Cerodontha* Rondani, *Calycomyza* Hendel, *Amauromyza* Hendel, *Liriomyza* Mik, *Lemurimyza* Spencer, *Phytagromya* Hendel, *Paraphytomyza.* Enderlein, *Phytoliriomyza* Hendel, *Pseudonapomyza* Hendel, *Napomyza* Westwood, *Indonapomyza* Sing and Ipe, and *Phytomyza* Fallen.

Under the section on immature stages eighty five species belonging to the genera *Agromyza, Japanagromyza, Melanagromuza, Ophiomyia, Cerodonotha. Calycomyza, Liriomyza, Lemnrimyza, Phytagromyza, Pseudonapomyza, Napomyza,* and *Phytomyza,* are treated. The most useful part of the publication would perhapes be represented by the Agromyzidae-Host-plant Index and the Host-plant-Agromyzidate index. A brief account of the geographical distribution of these insects is also added. Wherever possible the authors have given short accounts of the biology of the species discussed.

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STORED PRODUCT INSECTS AND THEIR CONTROL

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INTRODUCTION

The stored-product entomology during the last three years has taken up a new turn towards the goal of integrated pest control by reducing the use of conventional pesticides and employing biological, physiological and ecological methods. The trend of research in these areas have been catalogued in the present review. For convenience, the subject matter has been divided into 'Biology' ; 'Nutrition and Inhibitors' ; 'Insect and Storage Fungi' ; 'Ecology' ; Non-toxic Protectants' ; 'Pesticidal Protectants' ; 'Fumigants and Fumigation' and 'Pesticides and their residues'. In each area, the approach had been towards developing control methods against stored-products insects. In the following pages the literature on a few aspects of these subjects have been reviewed which are summarised for convenience of the reader.

In the field of 'Biology' of stored-products insects, major attention has been given to screen the resistant varieties of grains and seeds of wheat, paddy and pulses. Determination of loss in weight caused by infestation and the relationship with regard to the nitrogenous fertilisers for their effects on the susceptibility and resistance of high yielding varieties to infestation are also reported and relevant references have been cited in the review. Mites on stored grains with special reference to their hosts and predatory habit have also been studied.

Particular attention has been given by the research workers on the nutritional and dietary aspects of *Trogaderma granarium. Corcyra acephalonica, Tribolium castaneum* and *Cadra cautella* with the emphasis of identifying the factors limiting their growths, effects of *gamma* radiation on wheat starch and its components and the relationship of diapause in genetically heterogenous population of *Trogoderma granarium* to nutrition.

Quite interesting studies have been carried out on the relationship and association of fungi and stored-products insects. Even in a dry grain, various species of storage fungi associated with the freshly harvested wheat have been reported. Some species of Aspergilli promoted growth of rice weevil while the need for further work on the metabolites of fungi associated with rice and rice weevil is indicated. The mycotoxin and natural neurotoxin in the seeds of peanuts and *Lathyra sativus* were found to be related to the varietal and genetical characteristics. Development of techniques for the control of storage fungi based on gaseous sterilants, antifungal agent and chemical dehydrating agents have been studied during the period. Investigation on storage environment including the role played by structures and containers on the degree of infestation by pests and parameters for assessment of losses, studies on the ecological factors such as temperature and humidity on major stored-product insects and use of physical barriers for restricting the activities of storage insects and fungi, design of solar heated air dryer and storage structures received special attention.

The field of non-toxic protectants and the conventional pesticides, as prophylactic agents within the permissible limits, received tremendous impetus and attention of the investigators. Significant findings on *Becillus thuringiensis*, tricalcium phosphate, *Annona squamosa*, *Melia* sp., *Azadirachta* sp., Pyrethrin, Magnesium carbonate, Malathion and Captan are reviewed. A new medium for bacterial bepidoptericide, granular formulation for *B. thuringiensis* spores, effect of purity of tricalcium phosphate on its insecticidal potency, mode of action of tricalcium phosphate on *Corcyra* and *Periplaneta* using ^{45}Ca and ^{32}P were investigated and results reported.

Fumigants and fumigation were investigated more from the angles such as resistance stages of fungi to some fumigants, bio-physical aspects of gaseous sterilization, behaviour of PH_3 and mixtures of fumigants, disinfestation of cargo on ship carrying infestation of *Rhizopertha, Tribolium* and moths, bioassay of fumigant concentration, determination of Dichlorvos, development of paper strip detector for Phosphine, analysis of residues of methyl iodide as a fumigant and the charactertisation of volatile components in the conventional pesticide BHC by GIC and TIC are the significant advances.

The field of stored-product entomology did not neglect the implications of disinfestation and disinfection of products with chemicals with special reference to the residues. Apart from the studies on the selective rodenticides, investigations were made on the samples of grain and stored food products with respect to the load of pesticides which they carried. Toxicological and pharmacological studies on pesticides using cytological and histopathological techniques on rat tissues have also been reported. A number of methods for the analysis of residues suitable for biological laboratories have also been attempted. Finally, the pesticide residue analysis using test organism such as insects, fish and related assay organisms have been screened and a 'Toxicity Unit' for measuring pesticide residues in foods has been suggested.

BIOLOGY

During the period of review (1970-1973) the investigations on the stored product entomology were directed to screen the resistant varieties of grains and seeds, with the contention of minimising the requirements of pesticidal treatment.

Atwal and Dhaliwal (1971) investigated on the growth of Khappa beetle, *Trogoderma granarium* on different varieties of wheat. Their studies indicated that the multiplication rate varied with the varieties such as PV 18, Kalyansona, 227, S308, C306 and C273. With the rate of daily increase, *T. granarium* was capable of multiplying 1.736 and 2.411 times per week on PV 18 and C237 respectively.

Abraham *et. al.* (1972) selected 14 varieties of paddy grains with 14 percent moisture and containing amylose ranging from 15.9 to 41.8 per cent. These varieties were subjected to natural infestation by *Sitotroga cerealella* for a period of 3 months. Susceptibility to infestation by the pest was revealed by the percentage of damaged grain ranging from 0.13 in PTB-7 to 5.12 in Taianam-3. The varietal differences appear to be significant. The amylose content of the grain and the percentage infestation were found to be unrelated.

Gibson and Raina (1973) recorded for the first time *Bruchus iretis* as the pest of lentils in New Delhi. It lays eggs on immature pods in the field and the larvae penetrate the seed, feed, mature and emerge as adults from the stored seeds. The life cycle is comparatively long, nearly 6 to 8 monthes.

Raina (1971) infected *Callosobruchus analis, C. maculatus* and *C. chinensis* on chick peas. The reportedly resistant strain of the seed was tested along with 14 other common varieties of chick pea, employing two methods- selective preference and no choice. The strain (G109-1) was claimed to be significantly resistant as compared to other varieties, on which egg laying by bruchids was preferred. It was observed that the spiny character was absent in the susceptible varieties while G-109-1 the resistant variety had a rough seed coat, Singh and Talluri (1972) in their studies on the relative resistance on some varieties of Peas (*Pisum sativum*) to *Callosobruchus chinensis* reported that out of the 15 varieties of pea seeds tested for their degree of susceptibility to the insect, not a single sample was completely resistant to the attack of the insect. Varieties T-19, 6115 and GC142 were highly susceptible, while G477 and T163 were comparatively resistant. They concluded that the susceptibility or the resistance was governed by the interaction of many factors such as size, volume, protein content and other factors.

Gokhle (1973) on the basis of growth index found that moth bean had maximum food value to *Callosobruchus muculatus* as compated to green gram, pigeon pea, cow pea, bengalgram, chick pea. black grain, pea and other beans. The infestations in these were in descending order. An appreciable difference in the mean weight of adults emerging from these seeds was also recorded. Further Gokhle and Srivastava (1973) observed the influence of the french bean seed coat as an ovipositional attractant for pulse beetle, *Callosobruchus maculatus* (*Fab.*)

Of the 45 varieties examined by Janarthanan (1973), 32 were highly susceptible and 12 tolerant and one was highly susceptible out of the seeds of *Dolichos lab lab* tested against *C. chinensis.*

Singh *et. al.* (1972) determined the loss in weight caused by *Sitophilus oryzae* Lin. to various high yielding varieties of wheat. The average amount of grain damage by weight, number and amount of grain consumed per grub during development from egg to adult, were found to be different in different varieties. The average loss in weight, percentage damaged grain and consumption per grub were 1.5 to 2.3 per cent, 13·2 to 22.7 per cent and 9.75 mgs to 13.5 mgs respectively. The mean weight of each adult produced was 2.1 mg to 2.4 mg 30°C and 75% R. H.

Several high yielding varieties of wheat grain under different nutritional levels were subjected to rice weevil (*Sitophilus oryzae*) for determining their susceptibilities to the pest. The varieties *S. sonora* and larmarojo were observed to be least susceptible and the varieties S307 Sonalika were highly susceptible. Most of the varieties under the test were observed to be more susceptible to 'No level' where the host plants were not provided with any nitrogenous fertilizer. The authors, Chakravorty and Mathew (1972), claimed that varieties behaved differently in their susceptibility to *S. oryzae* under different nutritional conditions. Only Sonora-64, Kalyansona and S227, all other varieties showed significantly higher level of infestation at minimum nitrogen level.

Rao *et al.* (1972) reported on the susceptibility of dehydrated onions to the attack of *Cadra cautella.*

On mites, the work has been somewhat limited. Lal *et al.* (1973) reported on the new host of *Tyrophagus putrescentiae* mite was found in samples of flour and maize in which *C. cephalonica* were present. *C. cephalonica* failed to develop and surviving the attack of mite.

Somchoudhury and Mukherjee (1971) reared eggs of *Trogoderma granarium* of different stages of *Acaropsis docta.* The average duration of the different stages of the mite was : egg, 2.8 ; larva, 2.4 ; protonymph, 3.3 ; normal deutonymph, 2.8 ; and heteromorphic deutonymph, 26.6 days. The female laid on an average 9.3 eggs per day. The average oviposition period was 12.5 days. The number of eggs consumed by different stage of mite was larva, 2.4 ; protonymph, 4.6 ; normal deutonymph 3.7 ; heteromorphic deutonymph, 0·6 and adult, 4.4. Cannibalism was very common in this mite even in the presence of host eggs. *A. docta* was predated on *Tribolium castaneum* Herbst. *Corcyra cephalonica* Staint by some unidentified mites.

NUTRITION AND INHIBITORS

Sehgal and Agarwal (1973) studied the quantitative dietary requirement of *Trogoderma* for cholesterol and choline. Results indicated that cholesterol in amount of 0.031 and 0.0362 mg/gm diet did not support growth, and 2 mg cholesterol per gm diet gave optimal growth. Lanosteol, isocholesterol, 6-ketocholesterol and cholecalciferol did not act as sparing sterol in the presence 0.015 and 0.03 mg cholesterol/gm diet. Cholesteryl methylether and cholesteryl chloride inhibited the growth of larvae in the presence of normally sufficient amounts of cholesterol. Choline was essential for growth and the optimum growth was found at 50 microgram per gram diet. It can only poorly be substituted by triethanolamine, gamma-butyrobetaine and carnitine.

A method has been standardised to estimate small quantities of food intake by larvae using lebelled calcium by Gupta and Radhakrishnamurthy (1971). The early instar larvae of *Corcyra cephalonica* and *Tribolium castaneum* were found to consume more diet per unit weight than older ones. *Pyrethrum* and *Ziram* incorporated in the diets at 1-3 percent levels inhibited the diet intake of *C. cephalonica* larvae.

Bioassay of trypsin inhibitor from lentil (*Lens esculents*) and french beans (*Phaseolus vulgaris*) on Khapra beetle *Trogoderma granarium* was carried out by Bhattacharya and Pant (1970). On a later study, Bhattacharya and Pant (1971) reported that wheat flour suppresses the activity of inhibitors and increases the dietary efficiency of lentil and French bean for *Trogoderma granaria* Everts. This antagonism or inhibitory activity is less marked in green gram and least in semi-synthetic glucose yeast mixtures. Such inhibition in antagonistic properties of lentil and french bean has been demonstrated by them in their study on the factor inhibiting growth using natural diets.

Biochemical investigations (Radhakrishnamurthy, *et al.* 1971) on toxic factors present in guar bean were carried out using the growth pattern of *Corcyra cephalonica.* The larval growth was retarded by the saponin as well as by the toxic component isolated from Guar bean (*Cyamopsis psoralioides*). The saponin rich fraction from guar bean was not inhibitory to *Tribolium castaneum* larvae, whereas, the protein fraction containing the toxic component at 10% level exerted growth inhibitory effect.

Effect of gamma radiation on wheat starch and its components was investigated by Ananthaswamy *et al.* (1970). The results indicated that the initial reducing sugar formed as a result of irradiation of starch was an index of susceptibility to radiation, Radiolytic breakdown products were characterised and action patterns of *alpha*, and *beta* amylase, hydrolases were studied to elucidate their nature in relation to enzymic hydrolysis. Amylose and amylopectin were more susceptible to enzyme actions compared to their unirradiated controls. From irradiated starch, series of oligosaccharides of the maltose series were discernible, whilst glucose did not appear until the 200 Krad dose level. At high dose level maltose, maltotriose and Maltotetrose were the main products.

Nair and Desai (1972) reported on the influence of temperature, population density and nutrition on the incidence of diapause in a genetically heterogenous population of *Trogoderma granarium.* At 30°C about 35% of the larvae went into diapause when reared in isolation on wheat flour or maize flour. But no diapause occurred at 30°C when larvae fed on wheat or maize flour moistened with water and dried subsequently, showed severe retardation in the growth rate and eventulally entered diapause at 30°C. This effect was reverted by exposure to 35°C and supplementing the diet with yeast, Treatment of wheat flour with a mixture of chloroform and methanol produced similar effect. It was claimed that diapause exhibited in isolation as a Density Independent diapause (DID).

Studies were carried out on the effect of food, on the susceptibility of *Cadra cautella* wlk. and *T. granarium* Everts to PH_3 when reared in wheat bengalgram and groundnut. Baskaran and Mookherjee (1971) reported in this study that the larvae of *C. cautella* reared on groundnut were significantly more susceptible when compared with those reared on Bengalgram. Similar trend was noted in *Trogoderma* grubs showing greater susceptibility when reared on groundnut in comparison with either wheat or Bengalgram. Eggs of both the insects from groundnut were relatively more resistant to PH_3 than those reared on other two foods.

INSECT AND STORAGE FUNGI

Insects of stored products are invariably associated with fungi. Either the fungi are essential for their growth or bring about damage to grain or seed Toxins are also produced by their joint activities. Some interest have been evinced by research workers in recent years.

Dhanraj *et al.* (1972) conducted surveys on the fungi associated with wheat around Ludhiana and found that the wheat does not contain more than 10 per cent moisture during harvest in a normal season. Inspite of the low moisture content various species of storage fungi associated with freshly harvested wheat were isolated from 200 seeds in random samples. The species of fungi such as *Aspergillus. flavus. Penicillium chrysogenum* and *A. syowii* were isolated even in these dry grains.

Srinath *et al.* (1973) reported on the influence of some Aspergillus species on the population of *Sitophilus oryzae* L. They observed that *A. flavus* infected sorghum grain retarded the population of rice weevil. Further studies were made with the isolates of *A. flavus* obtained from grains (rice, peanut and maize), and also rice moth *Corcyra cephalonica* St. and rice weevil *S. oryzae* L. on their effects on the population of rice weevil. Isolates of *A. flauvus* from maize did not inhibit the breeding of rice weevil whereas other isolates tested inhibited the population to various degrees. Out of the Aspergilli, *A. versicolor* and *A. ruber* increased the population growth of rice weevil on rice. Further work in these lines on the metabolites of the fungi associated with rice and rice weevil will be interesting.

Nagarajan (1973) reviewed the approaches for preventing aflatoxin contamination and reducing the neurotoxin in foods. The possibility of exploitation of the genetic variations in aflatoxin producing capacity in certain food erops such as groundnut, soyabean, sunflower seeds and maize and the techniques for reducing the neurotoxin content in the seeds of *Lathyra sativus* are reported. About 30 varieties of groundnuts, 5 varieties each of soya bean and sunflower seeds and 7 varieties of maize have been screened for their alfatoxin producing capacity using toxigenic strains of *A. flavus* and *A. parasiticus*. A globulin like fraction is present in higher concentration in opaque-2 variety of maize and therefore the toxin producing capacity of infected opaque-2 is markedly reduced. *Lathyra sativus* in staple food, on excessive intake over long periods, leads to an irreversible paralysis in about 2 per cent of rural population. Presence of a powerful neurotoxin, beta-n-oxalyl, aminoalamine in the seeds has been detected. Steeping of the whole seed or dhal in hot water for an hour and rejecting the steep water or parboiling the seed as in the case of paddy reduces the toxin. Investigation on 600 samples have shown a wide variation in toxin content and varieties have been identified which have very low toxin content (less than 0.1%).

Basappa *et al.* (1972) reported that the conventional method of isolation of protein from groundnut cake flour containing aflatoxin results in concentration of the toxin in protein. Nearly 60 per cent of the total toxin is concentrated in protein fraction.

Nagarajan and Bhat (1973) while screening peanut variety on the production of aflatoxin by *A. flavus* and *A. parasiticus* concluded that the levels of aflatoxin production in peanuts differed significantly with the genetic variety of the plant and with the species and strains of the invading fungus. Possibilities for identifying groundnut varieties partially resistant to aflatoxin production are discussed.

Majumder (1973) studied the techniques for preventing the development of toxins in foodgrains during preharvest period and storage. The prevention of production of mycotoxins such as candidotoxin, islandotoxin, leutoskyrin, citrinin, aflatoxin and gibberllin depend entirely on the prevention of fungi responsible for their elaboration. The safe moisture levels for preventing fungal growth in cereals are below 11 per cent while in the case of oilseeds and pulses the moisture content should be below 9 per cent under the tropical ambient temperatures. Even in dry areas arthropod infestation results in inoculation of fungi. He reported on preharvest disinfection and prophylactic application of chemical protectants in the milky and post-milky stages of crops. Captan, thiram, zineb, propionic acid and acetic acid are most promising. Gaseous sterilants such as chloropicrin, ethyl formate, ammonia-phosphine mixture (1.5 : 1 w/w) and formulations of propylene glycol, ethylene oxide and methyl iodide in combination with EDB are to be applied as an adjunct to natural drying process.

Reduction of population of *S. oryzae* in grain treated with thirum was interpreted by Raghunathan *et al*, (1971) due to the following factors: (1) antifudant action of thiram, (2) direct action of thiram preventing the breeding of insects, (3) indirect action of thiram by reducing the quantity of fungi in the grains and thus making the grains less nutritious to insects.

Rangaswamy *et al.* (1971) studied further on the conditions of use of thiram as an antifungal agent during storage of grain sorghum. It was found that sorghum at 15 per cent moisture content can be protected from fungal infection for 180 and 30 days at 80% and 90% RH respectively. Thiram was inhibitory against the toxigenic storage fungi such as *Aspergillus flavus*, *Aspergillus candidus* and *Aspergillus orhraceus.* The rate of hydrolytic degradation of thiram was faster at higher moisture levels and beyond 15 per cent moisture content in sorghum, thiram became ineffective, while making observations on the breakdown of thiram at different moisture levels in stored grain sorghum, Rangaswamy, Poornima and Majumder (1971) contended that the critical moisture level for breakdown of thiram on sorghum was 13 per cent. The zone of slow degradation, can be advantageously employed for storing thiram treated sorghum in underground pit and related storage structures.

Captan (N-trichloromethyl thiotetrahydrophthalimide) has found its use both as a disinfestant and a protectant of grains and seeds. It is active against many soil-borne pathogens and reported to offer scope for preharvest prophylaxis against storage of fungi and pests. Therefore, a field test for the detection and semiquantitative estimation of Captan has been developed by Visweswariah, Majumder and Jayaram (1972). Monoethanolamine hydrolysis of captan for 10 minutes in a waterbath offered a quick and easy method as the colour of the hydrolysed mixture changed from pale yellow to deep blood red colour as the quantity of captan increased. In the presence of DDT, BHC isomers, BHC, aldrin, malathion and thiram, the compound would be supported or confirmed by the use of chromogenic agents like silver nitrate and ferric alum solutions.

Ananthakrishnan (1973) and Subramanyan (1973) investigated on the salt treatment for drying and protection of paddy.

A variety of permissible chemicals were tested by Subramanyan (1973) on wet paddy for preventing respiratory and other enzymatic changes during storage. In the case of paddy with 25% and more moisture content, treatment with dry salt (5-6%) has been highly effective through a rapid action in arresting undesirable changes such as heating, discoloration and development of foul odour. Other chemicals, effective in controlling deterioration in moist paddy were chlorine as vapour or as released from bleaching powder (0.3—0.5%) in preventing sprouting and spoilage for about 10 days. Addition of either urea (0.3%) or lime stone powder (1.0 to 1.5%) to the bleaching powder retarded the release of chlorine and prolonged the protection. Calcium propionate (0.5%) although arrested mould growth was costly and did not arrest germination unless the air supply was reduced.

ECOLOGY

Storage environment plays an effective role on the growth, development and bionomics of stored product insects. Their activities lead to certain physical and chemical changes in stored seeds and grains. Investigations on some of these aspects have been reported.

Parvathappa *et al.* (1972) studied the comparative storability and quality of jowar (*Sorghum vulgare*) in underground and above-ground storage structures in villages. It is reqorted that the infestation of sorghum stored in the structure was carried from the field or the farm premises. Germination and free fatty acids were affected in both but to a greater extent in underground storage. Insect count, kernel damage, total and true uric acid increased considerably in above-ground storage as compared to under-ground storage. Whereas apparent uric acid increased in underground pits.

Girish *et al.* (1972) in their studies on the preservation and losses of food grains in underground pits in U.P. determined temperature, oxygen concentration, moisture content, germination, damaged grain, insect, fauna, free fatty acidity (FFA) and alcoholic acidity on samples draw from two types of underground pits—i.e., brick masonary plaster with cement and mud plaster. There was lower germination percentage in the grain in the top layers as compared to deeper layers due to insect infestation and mould damage in both the *Khattis*.

Decrease in FFA and alcoholic acid was observed from top layers to bottom-layers in both the structures.

Pingale (1973) defined the losses in food grains and indicated that the real loss should include physical factors, biological factors and socio-economic factors in their computation. Loss in moisture, spillage and pilferage are physical losses. Attacks by insects, mites and rodents constitute the biological factors of loss.

Majumder (1973) while investigating on the characteristics of food losses in stored grain reported that the degradation of the kernels due to insects, fungi and moisture brings about physical and biochemical changes. Index of deterioration based on moisture, uric acid, glutamic acid, kernel damage, CO_2 production, fragment count, microbial counts, tetrazolium reaction, organoleptic quality and other visual characteristics indicates the soundness of grain. Basic information on the toxicological and nutritional impairment in addition to these deteriorative changes are yet to be obtained. There is a significant relationship between moisture and free fatty acids, fungi with apparent uric acid, kernel damage with insect count, fragment count and true uric acid. A high correlation between fungi and apparent uric acid-like substances, which give positive reaction to Benedict's reagent and produce coloured reaction complexes, has been observed.

Mukherjee *et al.* (1970) studied the incidence and extent of damage due to insect pests in stored leguminous and vegetable seeds and reported on a survey of the stored seeds in various ecological zones in India. Damage in leguminous seeds was mainly caused by bruchids, but *Trogoderma granarium* and *Rhizopertha dominica* were present in Bengal gram (*Cicer arietinum*). Leguminous seeds were comparatively more damaged, and a maximum of 32.6% due to bruchids was found on pigeon pea (*Cajanus cajan*). In cucurbitacious, solanaceous and other vegetable seeds as well as in oilseeds the maximum damage was 3%. A large number of seeds were found to be undamaged.

Girish and Krishnamurthy (1973) surveyed the loss in stored grains in rural areas in indigenous storage structures and cooperative stores. The loss at the village level can be reduced to a minimum level by using improved storage structures and scientific methods of insect and rodent control.

Sohi (1972) in his study on the larvae of *Trogoderma granarium* showed that the effective range of temperature for the photo-negative response of the larvae of *T. granarium* falls between 24°C to 39°C while low temperatures 13°C to 14°C and high temperatures 46°C to 49°C interfere with the normal photonegative behaviour and tend to slacken larval activity as affected by light. This behaviour of the larvae is not influenced by low and high relative humidities.

Adarsh and Sohi (1971) investigated on the effects of temperature and humidity on the development, survival, fecundity and longivity of *Callosobruchus analis*. The combined effects of temperature and relative humidity were studied on the development of the insect. The most favourable conditions were 30°C and 70% RH. Development did not take place at 40°C and at all levels of RH. The males lived longer and outnumbered females at all levels of temperature and RH. Higher temperatures were detrimental to the survival of female. The total number of eggs laid by a female during her life time and the rate of oviposition were maximum at 30°C and 70% RH. The shortest life cycle and maximum number of generation were observed at 30°C.

Bains and Atwal (1972) while investigating on the protection of grain against *Trogoderma granarium* and *Sitophilus oryzae* observed that *S. Oryzae* could not exist with high population of *T. granarium*. On the other hand, the rate of increase of *T. granarium* under condition favourable for quick multiplication of *S. oryzae* was very low. The storage structures should be such as to enhance unfavourability of the functional environment. In some parts of the country where sufficient rain fall during premonsoon, the moisture levels are expected to increase with a corresponding reduction in temperature. For such areas, structures capable of providing high temperature (35°C) and low humidity are to be devised. It will deny suitable conditions for growth of *S. oryzae*. The authors, however, claim that in dry areas where there is low rain fall, the moisture content of the grain is low and grain temperature is likely to be high. *S. oryzae* therefore is not likely to get an advantage over *T. granarium*. Hence. the storage structure providing comparatively low temperature will depress the population of *T. granarium*. In Ferozpur nnd Bhatinda districts the grain temperature in the *katcha* store are comparatively less than in *pakka* stores and infestation of the pests in the former is generally low.

Khare (1972) published a report on "Insect pests of stored grain and their control in Uttar Pradesh". Various topographic and climatic zones, types of storages of farmers are described. Details of the occurrence of pests in stores are given and an indication of their relative prevalence in various zones. Studies of losses in storage are described, alongwith the methods of sampling and assessment. Experiments on protectants in storage included aluminium silicate, silicagel and cow dung ash, vegetable products such as *Acorus calamus* and *Cannabis sativus* and a few organophosphorus compounds. Fenitrothion gave maximum proiection against infestation. Mixing of the inert dusts, fumigation with ethylene dibromide and a structure having moisture vapour barrier (Bitumin impregnated hessian cloth) proved very effective.

Relation of aeration to the growth of fungi and the resulting effect on grain quality were investigated by Chauhan *et al.* (1972). They conducted studies on the effect of aeration on grain stored in bulk in out-door silos to obtain data on the condition of the grain before and after aeration. Three metal silos of 6-tonne capacity were installed and filled with wheat variety Kalyan in December 1970 and emptied in May, 1971. Bin-A was ventilated by airing the grain by means of cowls turned into the wind and connected with perforated pipe in the middle of the bin. Bin-C was forced ventilated by ½ H. P. motor fan unit connected to the air duct. Bin-B served as unventilated control. It was noted that the increase in fungal activity was minimum in the forced aerated bin (C) and was maximum in unventilated bin (B). In Bin-A (natural ventilated by cowls), the total fungal population was mid-way between those of bins C and B. The results indicate that air reduces the fungal activity to a significant extent. The number and kinds of storage fungi present in the grain give some measure of the condition of the grain in storage which should serve to predict storage behaviour of grain and the extent of actual damage. It is suggested that in future, bin evaluation experiments as the parameter of storage fungi in the stored grain be included in the light of this report.

Girish *et al.* (1972) developed an easy method for detection of the eggs of *T. castaneum* and *Trogoderma granarium* in milled products. Supersaturated solution of Sodium chloride with specific gravity of 1.19 was prepared, the debris was mixed with the solution and the scum floating over the solution was collected, The scum was mixed with tap water and centrifuged for 5 minutes at 2000 rpm. The sedimented material was taken on glass slide and was examined under the microscope. The eggs of the above mentioned species of stored grain insects could be detected by this method rapidly.

Srivastava and Sareen (1972) reported that for retention of viability over a long perlod storage of soyabean at 11.5 per cent moisture, the sealed polyethylene bags were suitable at 20-84 percent R.H. and temperature 14-27°C.

Kempe-Gowda (1973) reported on the design of solar heated air for drying of agricultural products. In a similar study Kuppaswamy (1973) discussed the possibility of utilising solar heat for producing hot air needed in a mechanical drier. A workable godown roof which is designed to serve both as solar heat collector and as the roof covering have good possibilities for drying and disinfestation.

Ellis (1973) studied the design consideration, technical consideration and specifications for storage structures for preventing storage losses. He narrated the factors such as types of storage, constructions, materials, functional requirements, environmental requirements, human factors, equipment and accessories which are directed toward achieving ecology of storage.

NON-TOXIC PROTECTANTS

In the attempt for evolving integrated pest control nonconventional methods of control of pests received some attention of research workers. Salts such as tricalcium phosphate, plant insecticides, bacterial pathogens and pesticides of low mammalian toxicities were chosen and investigated for their selective effects on insect pests.

A new medium for culturing *Bacillus thuringiensis*, as the active ingredient in bacterial lepidoptericide, was developed by Nagamma, Raghunathan and Majumder (1972). It consists of groundnut cake, tamarind kernel powder and agar. The quantity of agar in the medium was brought to 0.5% by adding tamarind kernel powder. A spore yield (85% sporulation) of 3.2 g/1 was obtained. Bacterial spore produced on the new solid medium were pathogenic to the larvae of the almond moth, *Cadra cautella* which was used as the test insect.

Survival of the spores of *Bacillus thuringiensis* in granular formulation has been tested under storage conditions in the laboratory and also outdoor conditions exposed to weather by Ahmed, Nagamma and Majumder (1973). The granular formulations were prepared with attapulgite and aqueous and non-aqueous carriers. The virulence of the spore formulation was tested on silkworm, *Bombyx mori* larvae. A 0.4% spore concentration, with an initial count of 64 x 10^6, gave ultimately 0.3 to 0.4 x 10^6 viable spores/gm of the granule after 248 days of storage in the room. The viable count of spores in the granules exposed to outdoor weather conditions fell rapidly within two days ; at the end of 65 days, it was maintained at between 3 x 10^4 and 12 x 10^4/gm of the granules. Optimum concentrations required in granules for 100% mortality of the test insect was found to be 0.4x 10^6 spores/gm ; at the rate of

50 mg of granules per 85 cm^2 of leaf surface. While studying the effect of toxicity of tricalcium phosphate on insects of stored grains, Rao, Venugopal and Majumder (1971) observed that the purity of the commercial samples had profound effect on their efficiencies. Low grades containing less than 95% purity were ineffective. Commercial samples conforming to higher content of $Ca_3(PO_4)_2$ than 95° were able to control population of *Tribolium castaneum* in wheat flour.

Gupta, Radhakrishnamurthy and Majumder (1972) assessed calcium contents, distribution and digestion of tricalcium phosphate on the cockroach, *Periplaneta americana* Lin. Calcium was found in the cuticle of twelve species of Lepidoptera and Hymenoptera. Tricalcium phosphate when fed to the cockroach, *Periplaneta americana* with diets, was toxic at 5 per cent and above concentrations. Tricalcium phosphate labelled on calcium or phosphorus was fed to the cockroach and the distribution and metabolism of the compound (^{45}Ca and ^{32}P) studied with the aid of a Geiger Muller gas flow counter. The tissues of male cockroaches accumulated less activity than those of females. Haemolymph in the male contained maximum radioactivity in comparison to other tissues. In the female, the genital tissue and the haemolymph had high accumulation of radioactivity (^{45}Ca and ^{32}P). There was a steady decrease in the radioactivity in the tissues after the cockroaches were removed from the radioactive diet. The inner content of ootheca had more 32 P whereas the outer cuticle had more of ^{45}Ca.

Gupta *et al*, (1971) in their studies on the accumulation and distribution of tricalcium phosphate in the larvae of *Corcyra cephalonica* and *Tribolium castaneum* showed that the haemolymph and muscle—cuticle complex showed higher accumulation ^{45}Ca and ^{32}P. This was obtained by allowing the larvae to grow in media containing radioactive TCP compound containing ^{45}Ca or ^{32}P prepared in the laboratory. The radioactivity retained by the tissues increased with time and was highest between 24 and 72 hours. Even after a six days' exposure on non-radioactive medium significant radioactivity was detected in the tissues. Toxicological studies of the seeds of *Annona squamosa* on test insects such as *Stegobium panecium* and *Callosobruchus chineneis* were carried out by Vishweswariah *et al.* (1971). Of the different extracts obtained from the seeds, only the oily portion extracted with organic solvents possess appreciable toxicity to test insects. About 100 mg of the extract per 100 mg of food material was effective against *S. panecium* and *C. chineneis* but there was no action on *Trobolium castaneum*.

Teotia and Tewari (1971) powdered drups and leaves of *Melia azedarach* and *Azadirachta indica* and mixed with wheat seed at the rate of 1-2 parts, 4-8 parts per 100 parts of seed (w/w) respectively. The seeds were protected from damage by *Sittoroga cereallela* for a period of 135 days. Germination of seeds was unaffected.

Jaywal (1972) described the technique in which the gristed flour material left after extraction of pyrethrins is soaked in n-hexane when it gets disintegrated and raptured in 32 hours. This followed by distillation over water bath to desolventise and the residues is ground to a particle of 100 mesh for use in insecticidal formulation.

For the protection of wheat from damage of Khapra grub, protectants from plant products and magnesium carbonate were used by Sharma and Verma (1971). The data indicated that the protectants in the descending order of their effectiveness were neem seed, magnesium carbonate and costus root. The protection of the treated wheat seeds was not effective by any of the treatments.

PESTICIDAL PROTECTANTS

Bhatia *et al.* (1971) estimated LC 50 of Narayana strain of *Tribolium castaneum* and found it to be 37.76 times that of the susceptible strain Malathion They claimed the distribution of Malathion resistant strain in India. Studies on the resistance to insecticide in *Tribolium castaneum* were carried out by Bhatia and Pradhan (1972). They showed that the strain was more than 8.6 times resistant to Lindane as compared to the susceptible one. Cross resistance characteristics to 8 other insecticides was as follows—Dieldrin 291x, Heptachlor 232x, Endrin 165x, Aldrin 147x, Chlordane 34x, Endosulfan 8x, Toxaphene 9x, Carbaryl 12x, No cross resistence was indicated to Parathion 2x, Diaxinon 1.1x, Malathion 1x, ppDDT 0.7x and Pyrethrin 1.5x.

Viability of the maize seeds treated with some fungicides and insecticides during storage was studied by Saheran *et al.* (1972). They reported Captan among fungicides, was found to be very efficient in the retention of viability of maize. Among insecticides BHC was found to be very efficient than others.

Mukherjee and Misra (1972) reported on the relative toxicity of some organic insecticides to the larvae and adults of *T. castaneum.* Similar insecticides were evaluated by Rao and Pillai (1972) on the scale insect, *Aonidomytilus albus* Ckll. infesting tapioca tuber in storage.

Girish *et al.* (1972) claimed that Valexon was found to be more effective on jute bags than on cement concrete slabs although in both the cases it was superior to Malathion (50% EC), After 1 hour of spraying of Valexon at 3228 gm/sq.m. on concrete slab and 1614 gm/sq.m. on jute bags, a one hundred per cent mortality of *Tribolium castaneum*, *Sitophilus oryzae* and *Rhizopertha dominica* was recorded. *Trogoderma granarium* proved to be highly resistant to Valexon even at a dosage of 3766 g/sq.m.

Kashi (1971) tested Fenitrothion as a grain protectant on three species of stored products insects—*T. castaenum*, *S. oryzae*, *C. cephalonica*. As compared to Malathion, Fenitfothion (Sumithion) was superior while Diazinon was more effective than Fenitrothion against rice weevil and pulse beetle.

Srivastava and Dadhichi (1973) treated Bengal gram with 10, 20 and 30 ppm of Malathion and found these concentrations offer protection against attack by *C. maculatus* and *C. chinensis* for a period of 6, 7 and 8 months respectively.

Bhatnagar and Srivastava (1973) while investigating on the effect of fluctuating temperature on the toxicity of insecticides to *Tribolium castaneum* indicated that Malathion was more toxic followed by carbaryl and gamma-BHC.

Mohamed and Ahmed (1973) suggested that Malathion dosages of 1 to 10 ppm were effective only when applied to whole grain and for flour protection higher dosages were necessary. Similar trend was obtained with carbaryl. Degradation of carbaryl by wheat grain esterases as in the case of malathion was interpreted to be responsible for lower mortalities of *Tribolium castaneum* adults in wheat flour.

Bindra and Sidhu (1972) investigation on the dissipation of Malathion residues of maize in addition to dosage, stored condition and baking. After a storage period of 2 months, the residue of malathion in maize grains was 4.6 ppm from initial level of 20 ppm. The mean residues after 4, 6 and 10 months at 30 ppm dosage were 10.95, 7.75 and 3.85 ppm respecctively. The residues from 30 and 40 ppm dosage diminished to below the safe tolerance limit in 6 and 10 months, respectively. During processing of maize flour into chapati, 73 per cent of malathion dissipated.

Ahmed and Gupta (1973) in their studies on the stabilization of low toxicity plant insecticides for their prolonged residual efficacies against stored product insects and household pests, used water extract of deoiled neem cake which showed significant stabilizing property when combined with pyrethrins. The mixture containing pyrethrins, sesame oil, pyrogallic acid and bees wax when applied on glass, jute and grain surfaces at 31.5 mg, 330 mg/sq. meter and 5 to 15 ppm respectively, the persistence and residual toxicity were found to be similar to that of conventional pyrethrins piprenol butoxide (1 : 10) formulation. Tee bioassay in terms of LD 50 of pyrethrin formulation with neem extract and with piperonyl butoxide against *T. castaneum* and *S. oryzae* adults indicated that neem extract was not a true synergist but appeared to be a stabilizer of pyrethrins in the formulations.

FUMIGANTS AND FUMIGATION

Volatile chemical possessing fungicidal, insecticidal and nematicidal properties have the merit of not being persistent on the grains and food erops. Although, inherently these chemicals are volatile the phenomena such as absorption, adsorption and chemisorption lead to temporary or permanent residues. Hence the field of gaseous disinfestation not only invited toxicological studies but also physico-chemical and biological studies.

Proceedings of a symposium enlisted "Fumigation and gaseous Pasteurization" (Mukherjee and Venugopal, 1973), have been published which cover 'Toxic action of fumigants on insects", 'Some aspects of phosphine as a fumigant', 'Resistant Stages of fungi to some fumigants', 'Biophysical aspects of gaseous sterilization', 'Solids as carriers of gases', 'Certain volatile components in the by-product of lindane isolation process', 'Design of fumigation chamber' and 'Problems of manufacturing fumigants in India'.

Studies on the behaviour of EDB and Carbon tetrachloride mixture were carried out by Girish *et al.* (1972). During this investigation, the effectiveness of EDB, EDB : CT (1 : 8) and AIP at the rate of 60, 140, 4.8 gms/Cu/m. respectively were tested. Out of these fumigants, EDB CT mixture proved to be the best for controlling latent infestation.

Gupta and Chiblar (1972) investigated on penetration power and effective, ness of PH_3 using Celphos tablet at the rate of 60 tablets per 1000 cu.ft and the effectiveness of the fumigant was found to be directly proportional to the dose-exposure period, but inversely proportional to the depth to which it has to penetrate. Chendurker *et al.* (1972) reported on the behaviour of Phosphine gas in rat burrow. They found that phosphine penetrate and diffuse quickly over a large area surrounding the burrows.

Fumigation of packed materials in small quantities have been undertaken on board, in closed compartments used as storage rooms in ships. Pingale *et al.* (1972) for the first time tried fumigation of bulk wheat loaded in ship at Madras harbour containing 34,200 metric tonnes of wheat in three ships in 17 batches simultaneously with EDB-MB combinations, EDB alone and AIP alone. The dosages were 3.5 and 2.5 lbs. per thousand cu.ft. for EDB (7 days exposure period) and EDB-MB mixture (48 hours exposure period) respectively. In case of AIP, a dosage of 1 tablet (3 gm) per metric tonne with an exposure period of 7 days was tried. The results of the trials indicated that there was a 100% killing of insects such as *Rhizopertha* spp and *Tribolium* spp and the moths.

Sardesai (1972) reported that the diapausing larvae were more sensitive to HCN than normal larvae. Methyl bromide was also more toxic to diapausing larvae than the normal ones. Respiration was accelerated by HCN and MB increased CO_2 output in the diapausing form.

Minifume tablet developed by the Central Food Technological Research Institute, Mysore, was found effective in controlling infestation by *Sitophilus oryzae*, *Tribolium castaneum* and *Rhizopertha dominica* in stored sorghum seeds. Sithanathan *et al.* (1972) also observed that the effectiveness can be increased by placing it in different locations depending upon the shape and size of the container.

A bio-assay method for determining fumigant concentrations in air has been described by Muthu *et al.* (1971). The method is based on the premise that established concentration-time (CT) products divided by the knock-down time would yield the effective concentration of the fumigant. The CT products producing 100 per cent knock down of *Tribolium castaneum* (Herbert) adults have been determined at different concentrations of fumigants. The knock-down time in hours multiplied by the concentration provides the CT product value which can be utilised in assaying concentrations in fumigations. A glass-stoppered 'U'-tube containing *T. castaneum* adults is used as a gas sampling flask and the fumigant sample is scrubbed through it. The time taken for 100 per cent knock down is noted and is used as denominator to divide the CT product value. Data obtained for acrylonitrile, carbon disulphide, carbon tetrachloride, chloropicrin, ethylene dibromide, ethylene oxide, methyl bromide and phosphine are presented. The bioassay values closely followed the chemical analytical data.

Dichlorvos concentration in air was assayed by Muthu *et al.* (1873) using monoethanolamine for dehydrohalogenation. Volhard's titration and colorimetric procedure has been followed for the analysis in addition to the functional enzymic method. Due to the break-down of dichlorvos to dichloroacetyldehyde and other lower boiling compounds, bioassay proved to be difficult.

Muthu *et al.* (1973) developed a paper strip detector for detecting maximum acceptable concentration (0.05-0.3 ppm) of PH_3 in air. The strips were prepared by dipping filter paper in 1% solution of $HgCl_2$ in methyl yellow. The paper turned red in presence of phosphine. Ammonia interferes with the proper development of colour. The strips have been employed for the protection against phosphine in fumigation and degassing operations and also to detect traces of PH_3 in fumigate^{d} commodities. Muthu and Majumder (1973) further developed a chromogenic column for determining phosphine in air. The chromogenic reaction is based on the colour development with the following equation :

$PH_3+3HgCl_2=P(HgCl)_3+3HCl$; the HCl thus fromed lowers the PH which could be visualised by using a suitable PH sensitive stain. A solution of mercuric chloride (1%) in 0.1% cresol red ethanol impregnated into celite and filled into a glass tube (17.8 cm x 0.2 cm (i.d) could accurately determine even 0.06 Hg phosphine in air. The samples were injected quickly through a rubber septum cap on the glass tubes under low suction. A red coloured band developed instantaneously, the length of which was proportional to the concentration of phosphine. A 1:3 and 1:6 mixture of phosphine and ammonia produced two bands, a yellow band for ammonia preceeding the red phosphine band in the chromogenic column. Interference of ammonia with the development of phosphine band was discernible.

Methyl iodide has been found to be a candidate fumigant by Majumder (1972) to be effcctive against insects and fungi. Rangaswamy *et al.* (1972) developed colorimetric procedure for estimation of Methyl iodide residues by converting it into potassium iodide with methanolic KOH. Subsequently potassium iodide acts as a catalyst in the oxidation of As (III) by Ce (IV). Unreduced Ceric salt is further measured colorimetrically and the iodide in the sample is calculated. The method was employed on jowar and rice fumigated with methyl iodide for estimation of the residues and it is claimed that the sensitivity is in the range of 0.01 mg iodide.

Sorption of phosphine used as a fumigant on food stuffs was investigated by Muthu *et al.* (1973). Several commodities grown in the country were subjected to phosphine fumigation. Residual fumigant in intergranular space is recovered by scrubbing the fumigated material with nitrogen under recirculation, absorption in mercuric chloride and estimation by an iodometric method. On the basis of recovered phosphine the sorption levels in the products are computed. The sorption is quite high in the commodities, especially at the lower dosages. There is total loss of fumigant due to sorption in certain commodities like split pulses. The significance of this irreversible sorption of phosphine by the commodities needs serious examination.

Visweswariah *et al.* (1973) isolated volatile components of X-factor from technical BHC by column and gas liquid chromatography and made toxicity studies on test insects. TLC with normal hexane as mobile phase gave nine distinct spots when the chromatogram was sprayed with 2% *Ortho*-tolidine in acetone. Of these, eight spots were blue and one at the bases was pink in colour designated as X_4. This pink colour X_4 compound had no insect toxicity. Of the three unknown fractions, X_3 has been identified as a *new isomer* of hexachlorocyclohexane with significant insecticidal action. Between X_2 and X_1 only the X_1 component had fumigant action and insect toxicity. The X_1 fraction with fumigant action has been identified as *Ortho*-dichlorobenzene. Due to high solubility of the new isomer in *Ortho*-dichlorobenzene both contact and volatile toxicities are obtained against test insects.

PESTICIDES AND THEIR RESIDUES

During recent years the chemical control of pests has received a set back due to the recognition of the associated problem of pollution of the environment, health hazards to man, animals and wild life. Although, attempts are being made to screen safer, effective and selective chemicals by testing against target species for their control, attention is being increasingly given to the aspects of chronic toxicities to man and monitoring of the pesticide residues in treated products and environment for their safe application in pest control.

Laboratory evaluation of different anticoagulant formulations such as Rodafarin, Ratafin, Racumin, Pivalin and Drat at 0.025% concentration indicated that Rodafarin and Pivalin behaved better than others as the mortality period was less. All the anticoagulants, however, gave a 100% mortality within a period of 21 days as reported by Girish *et al.* (1972).

Effect of norbormide on blood glucose levels in albino rats was investi gated by Patil and Radhakrishnamurthy (1973). Norbormide at a toxic dose level (1-2 mg/100g body wt.), irrespective of the mode of administration, caused a significant rise in blood glucose levels with a concomitant fall in hepatic glycogen contents of albino rats. Two strains of mice were however, devoid of this effect. Glycogen contents of skeletal muscles and glutathione contents of liver were also decreased. Insulin though reversed the hyperglycemic effect, but it failed to protect the rats against other toxic manifestations and culminating morbidity.

In a study by Murthy and Patil (1971) on the effects of norbormide, a specific rodenticide, on the enzymes in the blood, intestine and liver of rat, the results have shown that the ATP aspase and the PI-ATP exchange reactions occur in presence of the compound. A general imbalance in the distribution of aminotransferase and phosphatases is also observed. Cholinesterases system have shown that there is an increase of this enzyme in one of the fractions of brain-(cerebella), intestine and plasma depending on the mode of administration of the compound.

Thackre *et al.* (1972) reported on the method for micro determination of DDT in oilseeds. Codistillation preceeded by alkali hydrolysis of the extract proved satisfactory clean-up step for the estimation of DDT residues in treated sample of the major oil seeds taken for their investigation. Under the experimental conditions DDT was converted to DDE which responded to Schechter and Haller colour reaction and codistillation quantitatively. Recoveries ranged from 90 to 114 per cent.

The mammalian toxicity of X-factor (a new isolate derived from by-product of tech-BHC after isolating Lindane), BHC and Lindane at 50 ppm levels on albino rates was investigated by Rao *et al.* (1972). Rao *et al.* (1972) while carrying out comparative toxicological studies on the new isolate, X-factor, and other components of BHC on albino rats reported that the metabolites were produced *in vivo* from the X-factor components. The residues in liver, kidney and whole body were extracted and estimated by the TIC method. Ethereal sulphate, glucuronic acid and mercapturic acid were estimated in the urine. At the end of the experiment haemoglobin content, red blood cell counts and white blood cell counts of all the animals were determined. Histological examination of liver and kidney was also reported. The results of these investigations indicated that X-factor metabolites was excreted as ethereal sulphate, mercapturic acid, glucuronic acid, conjugates to a less extent and accumulated more in tissues. The toxicity of X-factor was lower than the two insecticides tested in these animal experiments. It was also indicated that these insecticides offer little or no hazard from 50 ppm level in the diet of albino rats.

Examination of 214 samples draw from Hyderabad market showed that the average consumption of DDT by the general population is less than the accepted daily intake (Laxminarayana and Menon, 1972). Since DDT residues were higher in starchy vegetable and cereals, it was concluded that the rural and poorer sections of the population who depend mainly on starchy food for sustenance are more exposed to DDT.

Bhatia and Venkatsubramanyan (1973) reported the accumulation of fat in liver of rats during dieldrin toxicity which may be traced to the enhanced hepatic synthesis to triglycerides due to increased availability of free fatty acids and *alpha*-glycerophosphate.

Dixit (1973) ; Dixit and Dutta (1972) and Dixit and Dutta (1973) reported on the dermal toxicities of DDT, parathion, lindane and also intratesticular injection of lindane, endrin and other pesticides. Similar studies have also been reported by Dixit *et al.* (1973) on the cytological changes by endrin in albino rats.

Lal *et al.* (1970, 1971) ; Mukherjee (1971) *et al.* carried out histopathological studies of the organophosphorus treated insects. Symptoms of toxicity of these OP compounds on *Prodenia litura* were reported by them. Among stored product insects, *Sitophilus oryzae* (Mukherjee and Singh 1971) and *Tribolium castaneum* (Singh and Mukherjee, 1971) were selected by the group for studies on the structure of their alimentary canals, and the histopathological effects of pesticides.

Rangaswamy *et al.* (1971) estimated Zineb colorimetrically by reaction with cupric acetate in HCl. The copper salt formed is measured at 370μ. This method has been applied successfully to the analysis of Zineb formulations and its residues on grains and peanut pods.

Mukherjee and Mathew (1972) developed a rapid clean-up procedure for isolation of chlorinated pesticides in milk, fats and oils by direct silica-gel absorption instead of the use of any common clean-up procedure. Chlorinated pesticides are eluted from silica-gel with acetonitrile which is then partitioned in petroleum ether. A TIC method is employed for the identification and separation of the pesticide.

Qadri (1971) estimated Malathion residues on paddy, husk dehusk rice by bio-assay using flour beetle, pulse beetle and housefly, In a similar study Dichlorvos was bioassayed by him. The vapour toxicity of Dichlorvos (DDVP) to houseflies, flour beetle and rice wevlil showed that houseflies was 80.55 and 4.35 times more susceptible than flour beetle and rice weevils respectively. The method estimated 20 microgramme of Dichlorvos vapour in test chamber using house-flies as the test insects.

Visweswariah and Jayaram (1971) developed visual colour tests for the identification and semi-quantitative estimation of certain commonly used insecticides. These techniques are particularly interesting and useful in the detection and identification of the nature of pesticides in foodgrains meant for seed which are sometimes sold by unscrupulous merchants for human consumption. Various colour changes with monoethanolamine, and subsequently treated with silver nitrate solution, facilitates not only the broad classification of insecticides, colour standards prepared for different quantities of each insecticide will also help in the semiquantitative estimation. Aldrin, Endrin, Captan, Lindane, Malathion, Parathion, and Taxaphene have been found to give distinct colour reactions with the reagent.

While discussing on the implications of pesticides residues in foods and the development of selective protectants, Majumder (1971) included data on the distribution of pesticides residues in grains, seeds, animal feed, animal products and in plant and animal tissues. These residues were derived from the treatment of commodities for pest control. Results have been reviewed on their implications as residues on raw materials which are food stuffs and feeds in relation to dietary deficiency and climatic stress. Exposure to single and multiple residues results in either potentiation or detoxification in experimental subjects. The changes needed in the concept of residue determination and toxicological significance are elaborated in the light of parent materials, their decomposition products and metabolities and resultant reductions in the tissues of consumers. The validity of individual tolerances for residues is doubtful. The pesticide cycle and migration of terminal residues in the biosphere has been propounded by the author. In the light of the present status of the availability of pesticidal compounds, the promising products are listed and suggestions are made for minimising the environmental pollution. The need for developing selective pesticides and food protectants is stressed. Data on the role of comparative morphology and biochemistry, and comparative pathology in designing selective bio-degradable protectants with specific examples, such as meta-hydrogen halloy-site, tricalcium phosphate and wide spectrum formulation of *Bacillus thuringiensis*, malathion, Captan, Lindane and volatile pesticides and protectant are discussed.

Gupta (1971) reviewed several methods of determining insecticide residues viz., bioassay, colorimetry, measurement of radioactivity, enzymatic inhibition, paper chromatography, thin layer chromatography, etc., which are invogue. A comparison of the data on the amount of residues of a number of insecticides in different materials determined by bioassays and by chemical analysis has been discussed. He concluded that bioassays give as good results as the chemical analysis and wherever there is any discrepancy, bioassays give better assessment of the situation because what is more important is not the presence or absence of a particular compound but its biological activity.

Lal (1971) in his paper on the use of bioassay in pesticide residue analysis contended that the investigations to standardise bioassay method for the estimation of micro-quantities of insecticides and to determine their residues on different crops resulting from applications for pest control, so that time of application for their safe and effective use could be established. Five species of insects were used for the precise estimation of micro-quantities of insecticide residues several times less than the tolerance limit on different crops. *Drosophila melanogaster* bioassay was found to be as sensitive as the colorimetric method. The results on the dissipation of various insecticides as obtained by bioassay have been discussed.

The bioassay technique for determining insecticidal pollution of water was described by Dutt and Dass (1971). To determine insecticidal pollution of water arising out of granular formulation with *Cyprinus carpio* (American Rohu) and *Hetropneustis fossilis* (Singhi). TLm values have been recorded to serve as bio-indicators of the degree of pesticidal enotaminations in water.

Difficulties and errors in the use of bioassay techniques for residue analysis are encountered which are related to the selection of solvent, in perparation of the deposits in the selection and handling of the test insects, in recording mortality of the test insects, in the cleaning of glassware and finally in the interpretation of data. Deshmukh (1971) further pointed out that the loss of insecticide during evaporation, interference due to extractives and additives, centralised heating system, etc. are the usual factors which affect the bioassay results.

Quadri and Majumder (1970) proposed a "Toxicity Unit" for measuring pesticide residues in foods. Since the toxicity of a particular insecticide is modified profoundly by composition of the food and the ingestion is not limited to a single chemical, the manifestation of toxicity in man and animal is due to their joint action and not as a function of a single pure pesticidal compound. It is suggested to develop bioassay techniques for measurement of residues of toxic compounds in presence of the components of the food.

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TAXONOMY OF FISH

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INTRODUCTION

The period 1970-73, to which this summary of progress relates, is significant in two respects. Firstly, there has been an awakening of interest among fishery biologists on research on taxonomy of fishes that may eventually be used in the development and conservation of the fishery resources. Secondly, there is an increasing appreciation that the faunastically rich Indo-Malayan region, of which India is an intrinsic part, is one of the most poorly sampled for fish and it is, therefore, probable that this region shall provide most of the new taxa collected in the future.

(1) MARINE AND ESTUARINE FISHES

A book published in India entitled, *Bibliography of the Indian Ocean*, edited by Dr S. Jones (1971), containing references on Systematic Ichthyology, deserves special mention since it was intended to give the scientific workers a comprehensive idea of the publications relating to the Indian Ocean that have come up to the end of 1969.

Progress in taxonomic investigations on Clupeoid fishes has not been commensurated with the importance of this group in the fisheries of India. Talwar and Whitehead (1971) redescribed the types of Day's clupeoid fishes and designated lectotypes for the six species. Further, they established a new genus, *Dayella* for the reception of *Spratelloides malabaricus* Day, 1873, and considered, with a query, *Clupea suhis* Chaudhuri, 1912, and *Gadusia godanahiai* Srivastava, 1968, conspecific with *Gadusia variegata* (Day, 1869). Babu-Rao (1971) described a new anchovy, *Thryssa gautamiensis* from the Godavari estuary, and later (Babu-Rao, 1973) listed the clupeoids from this estuary. Babu-Rao and Jayaswal (1971) considered *Thryssa kempi* (Chaudhuri, 1916) as the juveniles of *Thryssa annandalei* (Chaudhuri, 1916). Dutt (1972) considered Cantor's (nec Cuvier and Valenciennes) *Kowala thoracata* identical to *Sardinella fimbriata* (Valenciennes). Dutt and Seshagiri-Rao (1972) described a new anchovy, *Coilia korua* from Gollapalem (Andhra Pradesh).

Seshagiri-Rao (1972) evaluated the taxonomic characters of the *Ilisha indica-megaloptera* species-complex, and proposed a new character, the striation pattern on the frontal bones, for distinguishing these two species. Whitehead (1973) gave an excellent paper of the Indian clupeoid fishes which is a synthesis of many recent but scattered papers on clupeoid systematics; it contains keys to all Indo-Pacific genera and all Indian Ocean species, and provides a framework for future work.

The Ribbon fishes of the family Trichiuridae are represented by four species in Indian waters and are the subject of one of the important commercial fisheries. Wheeler (1971) changed the scientific name of one of those, *Eupleurogrammus intermedius* (Gary, 1831) to *E. glossodon* (Bleeker, 1860) following the discovery that the specimens claimed by Tucker in 1956 to be the types of *Eupleurogrammus intermedius* could not be so. Other important food fishese whos specific status were fixed are the dominant species of *Platycephalus*, belonging to the family Platycephalidae, in the trawl catches of the Kerala coast and the common carangid, *Carangoides malabaricus* (Schneider, 1901). George (1970) identified the demersal flathead as *Platycephalus maculipinna* Regan, 1905, a species hitherto not reported from the Kerala coast and referred to as *P. scaber* (L.) in the fishery literature. Talwar (1973a) has shown that *Carangoides malabaricus* (Schneider) is a senior synonyn of *Carangoides rectipinnus* Williams, 1958, and redescribed the species.

The taxonomy of fishes of the family Sciaenidae received considerable attention in view of their commercial importance. Talwar (1970a) relegated *Dendrophysa hoogliensis* Sinha and Babu-Rao, 1960, to the synonymy of *Dendrophysa albida* (Cuvier, 1830) and later (Talwar, 1971c) establised a new genus, *Daysciaena* for the reception of the latter species. Trewavas (1971) confirmed this nomenclatural arrangement following the discovery of the syntypes of *Corvina albida* Cuvier, 1830, in the Paris Museum, and assigned the reports of "*Pseudosiaena albida*" from the western Pacific Ocean to a new species, *Nibea chui*; she redefined the genus *Nibea* and proposed a new genus, *Protonibea* for '*Nibea*' *diacanthus* (Lacepede, 1802). Talwar (1970b) relegated the sciaenid genus, *Bola* Hamilton, 1822, and its objective synonym *Wak* Lin 1938, to the synonymy of the genus *Johnius* Bloch, 1793, and considered the sciaenids with a hammer-shaped otolithini gas-bladder and a terminal mouth with differentiated teeth in both jaws, without an appropriate generic name. For these sciaenids, Mohan (1972) proposed a new genus, *Johnieops* with *Sciaena osseus* Day, 1876, as the type species but inadvertently treated the species also under the genus

Johnius. Talwar and Joglekar (1970a) proposed a new genus, *Dhoma* for *Corvina axillaris* Cuvier, 1830, and later (Talwar, 1971b, c) proposed two new generic names, *Cantor* and *Blythia* with *Corvina cuja* Hamilton, 1822, and *Umbrina dussumieri* Valenciennes, 1833, as the type species, respectively; *Dhoma* and *Cantor* are, however, clearly objective synonyms of *Kathala* Mohan, 1969, and *Macraspinosa* Mohan, 1969, respectively, having the same type species. Talwar and Joglekar (1970b) described a new sciaenid, *Wak menoni* from the Hooghly estuary and also recorded (Talwar and Joglekar, 1970c) *Wik goldmanni* (Bleeker) from the estuary, a species hitherto not reported from Indian waters. Both these species are now, however, referrable to the genus *Johnieops* Mohan, 1972. Talwar (1971d) clarified the specific identity of *Sciaena osseus* Day, 1876, and concluded that the records of *osseus* with 2+7 gillrakers require a new specific name. Talwar and Shetty (1971) assigned *Bola coitor* Hamilton, 1822, to the genus *Johnius* Bloch and redescribed the species. Talwar and Joglekar (1971) discovered *Otolithus versicolor* Cuvier, 1829, for the first time after its original discovery by Russel in 1803. Joglekar and Talwar (1971) recorded *Pennahia macrocephalus* (Tang) for the first time from Indian waters. Mohan (1971a) described a new sciaenid, *Johnius mannarensis*, from the Gulf of Mannar; with a single mental barbel and hence referrable to the genus *Blythia* Talwar, 1971. Talwar and Joglekar (1972a, b) elucidated the systematic status of *Sciaena bleekeri* Day, 1876, and *Otolithus vogleri* Bleeker, 1853, respectively and designated a lectotype for the former species. Mohan (1972) classified the sciaendid fishes of India into five subfamilies based on the structure of the gas bladder, and presented a key to the identification of the various genera. Druzhinin (1972) discussed the geographical distribution of the fishes of the families Sciaenidae and Lutjanidae, in the Indian Ocean. Trewavas and Talwar (1972) resurrected *Bola chaptis* Hamilton, 1872, from the synonymy of '*Pseudosciaena*' *diacanthus* (Lacepede, 1872) and gave it a new combination, *Bahaba chaptis* (Hamilton) based on specimens from Burma. Talwar and Datta (1972) subsequently discovered this species from the river Ganges, its type locality and designated a neotype. Talwar and Sinha (1973) designated a neotype for *Johnius carutta* Bloch, the type species of the genus *Johnius* Bloch. Mohan (1973) synonymised *Otolithoides brunneus* (Day, 1873) with *Otolithoides biauritus* (Cantor, 1850) and discussed the specific status of Dutt and Thankam's *O. brunneus* (Day).

Extensive researches on the Cynoglossid flatfishes were undertaken by Menon (1971a) who showed that the correct scientific name of the Malabar

Sole is *Cynoglossus macuostomus* Norman, 1928, and not *C. semifasciatus* Day, 1877, as per fishery biologists; he relegated *C. luctuosus* Chabanaud, 1947, described from Tanur (Kerala), to the synonymy of the former species. Seshappa (1971) studied the lateral line sensory canel system in *Cynoglossus* Day *semifasciatus*(=*C. macrostomus*), an important taxonomic character in this family of fishes. Kutty, Narayanan and Mathew (1972) confirmed the occurrence of of *Cynoglossus dubius* Day in the deeper waters off the south-west coast of India, and redescribed the species. The Soleid flatfishes were studied by Joglekar (1971a, 1972) who described two new taxa, *Aseraggodes steinitzi* from the Red Sea and *Chabanaudetta smithi* from Thailand. Further, she (Joglekar, 1971b) reported *Liachirus nititus* Gunther for the first time from the Red Sea.

The mullets (family Mugilidae), an important food fish of the Hooghly estuary, were studied by Joglekar and Babu-Rao (1970) who concluded that speciation in mullets of this estuary is very intricate and it is possible that interbreeding might also be taking place between different "species". Vijaya-Gupta and Gopalakrishnan (1970) studied the taxonomy of *Polynemus paradiseus* L., belonging to the family Polynemidae in the Hooghly estuary and concluded that the variation in the free pectoral fin filaments is not a definite diagnostic character for polynemids,

The taxonomy of the Gobioid fishes also attracted considerable attention. Rangarajan (1970) described a new species, *Callogobius mannarensis* from the Gulf of Manner. Miller (1971) recorded for the first time *Parioglossus dotui* Tomiyama, 1958, from Indian waters. Visweswara-Rao (1971a, b, c) described two new gobioid genera, *Incara* and *Chiramenu*, and eight new specics namely, *Incara multisquamatus*, *Chiramenu fluviatilis*, *Callogobius melanoptera*, *Paragobiopsis orbiculdris*, *Silhouettea indicus*, *Stigmatogobius yanamensis*, *S. micrognathus* and *Ctenogobius godavariensis*, and later (Visweswara-Rao, 1972) *Waitea buchanani* from the Godavari estuary.

The badly neglected group, family Blenniidae was studied by Smith-Vaniz and Springer (1971) who characterised the blennid tribe Salariini and gave a key to the identification of the 24 genera: Springer (1971) revised the Indo-Pacific genus *Ecsenius* and relegated *Salaries burmanicus* Hora and Mukerji 1936, to the synonymy of *Ecsenius bicolor* (Day, 1888). Springer (1972) characterised the blennid tribe Omobranchii and revised all genera of this tribe except *Omobranchus*; he listed all the nominal species with their current scientific names and gave the repository of their type material. The syntype of *Petroscirtes bipunctatus* Day, 1876, erroneously stated as lost by Springer (1972), is however, deposited in the collections of the Zoological Survey of India under registration no. 2080. Closely related to the blennids are the fishes of the families Clinidae and Tripterygidae, and these were studied by Mohan (1971b), Talwar and Sen (1971), and Shen (1971). Mohan (1971b), and Talwar and Sen (1971) described two new taxa under the genus *Helcogramma* viz., *H. shinglensis* from the Gulf of Manner and *H. indicus* from Madras, respectively. Shen (1971) considered *Cristiceps halei* Day, 1888, conspecific with *Clinus xanthosoma* Bleeker, and proposed a new genus, *Springeratus* for the reception of the latter species.

The shallow-water Brotulids were studied by Visweswara-Rao (1970b), and Menon and Rama-Rao (1971a, 1972). Visweswara-Rao (l.c.) studied the generic relationship of *Brotula jerdoni* Day referring it to the genus *Sirembo*, a combination later confirmed by Menon and Rama-Rao (1971a). Menon and Rama-Rao (1972) recorded the brotulids, *Brotula multibarbata* Schlegel and *Dinematichthys iluocoeteoides* Bleeker for the first time from the Andaman Sea.

The frog-fishes of the family Batrachoididae were studied by Nagabhushanam and Rama-Rao (1970) who made a preliminary taxonomic study and presented a key to the identification of the two species of the genus *Halophryne*.

James (1971b) gave a detailed account of the structure of the teeth in the ray, *Rhinoptera javanica* Müller and Henle, a salient taxonomic character for specific separation. James (1971d) redescribed the ray, *Gymnura poecilura* (Shaw) and described the species with or without a small caudal spine, evidently confusing two species.

The bathypelagic fishes of India drew comparatively little attention of taxonomists in view of the inherent difficulties in collecting them. Menon and Rama-Rao (1970a, 1971b) catalogued the Type-specimens of fishes collected by the R.I.M.S. "Investigator" (1884-1926) omitted in the previous series (*Rec. zool. Surv. India, 61* : 91-190) dealing with the Types housed in the Zoological Survey of India, Calcutta. Kartha (1971) described a new paralepid, *Lestidium blanci* from south-western India, and Talwar (1973a) recorded the adult of *Lestidium japonica* Tanaka for the first time from the Indian Ocean. Silas and Prasad (1971) discussed the family relationship of the genus *Psenes* Valenciennes, 1833, and the systematic status of *Psenes indicus* (Day, 1870) and its specific synonyms. Compagno and Springer (1971) recorded the carcharhinid shark, *Eugaleus omanensis* Norman, 1939, off the Gulf of Kutch, erected a new genus, *Iago* for its reception and redescribed the type species. Nair and Mohan (1971) recorded the shark, *Echinorhinus brucus* (Bonnaterre) for the first time from the east coast of India. Later, Nair and Mohan (1972) reported the spiny dogfish, *Centrophorus armatus* (Gilchrist) also from the east coast of India, and discussed its generic relationship. Eschmeyer and Rama-Rao (1972) described two new scorpionfishes, *Scorpaenodes investigatoris* and *S. smithi*, the former species being based on material collected off western India by the R.I.M.S. "Investigator" and the International Indian Ocean Expedition, and the latter on the British Museum material from the Andaman Sea. Rama-Rao (1972) listed three new distributional records of scorpionfishes, *Pontinus tentacularis* (Flower), *Ocosia vespa* Jordan and Starks, and *Setarches longimannus* (Alcock) from off the Kerala coast. Cohen and Nielsen (1972) recognised the genus *Saccogaster* Alcock, 1889, as a senior synonym of *Batbuliceps* Chan, 1966, and discussed the relationship of its type species, *Saccogaster maculata* Alcock with its other known species. Nair and Mohan (1973) described a new species of skate, *Rhinobatos variegatus* from the Gulf of Mannar and gave useful taxonomic notes on *Eugaleus omanensis* Norman, *Eridaenis radeliffei radliffei* Smith and *Halaelurus hispidus* (Alcock); they relegated *Proscyllium alcocki* Misra, 1950, to the synonymy of *Eridacncis radcliffei.*

Four official documents on the taxonomy of marine fishes, which were distributed by the Indian Council of Agriculture Research but not officially published, deserve special mention. The first was by nair, Virabhadra-Rao and Dorairaj (1970) who peesented the basic information on the taxonomy of the tunas and tuna-like species in and arround the seas of India, and the second is on the Indian mackerel, *Rastrelliger kanagurta* (Cuvier) and its allied-species by Virabhadra-Rao (1970) who discussed the systematics and geographical distribution of these commercially important species. The third and fourth are on the taxonomy of the dolynemid fishes of India and the Bombay duck, *Harpodon nehereus* (Hamilton) by Kagwade (1970) and Bapat (1970) respectively.

Among the faunastic accounts, the work of Jones and Kumaran (1970, 1971) on the fishes of the Minicoy Island in the Laccadive Archipelago, is noteworthy, They continued their valuable series entitled "New records of fishes from the seas around India" wherein they recorded 24 species not known hitherto from the Central Indian Ocean and described one new species, *Abudefduf manikfani.* Nagabhushanam and Chandrasekara-Rao (1972) also studied the ichthyofauna of the Minicoy atoll and listed 350 species of which several are new distributional records. Dmitrenko and Fursa (1970) studied the marine ichthyofauna of the Kathiawar coast (Gujarat). Menon and Talwar (1972) studied the fish collections of the Great Nicobar Expedition, 1966, and added 12 species to the ichthyofauna of India, including a new kraemeriid, *Kraemericus smithi.* Rama-Rao 1973) listed 153 shore fishes from the Coromandel coast, Palk Bay and Gulf of mannar. Selvanathan and Kaliyamurthy (1973) listed 81 species from Pulicat Lake (Madras), the majority of which are of marine origin. Talwar (1971g, 1973c) studied the shore fiishes of Goa and listed 169 species. Besides these, other interesting additions to the marine ichthyofauna of India, during the period under review are: the flying fiish, *Hirundichthys speculiger* (Valenciennes) by Menon and Rama-Rao (1970b); a new callionymid, *Callionymus jonesii* from the Palk Bay by Mohan (1970); *Acanthosphex leurynnis* Jordan and Seale by Ramaiyan and Rao (1970); *Hetereleotris zonatus* (Flower) by Visweswara-Rao (1970a); a new species of silverbelly, *Leiognathus jonesi*, and the pipefish, *Micrognathus brevirostris* (Ruppell) by James (1971a,c) respectively; *Ulua mandibularis* (Macleay) and *Anyperodon leucogrammus* (Cuvier and Valenciennes) by Luther (1971, 1972) respectively; *Hoplolatilus fronticunctus* (Günther) by Talbot (1971); *Ambassis kopsi* Bleeker by Talwar and Chakrapany (1971); *Tetrosomus concatenatus* (Bloch) by Kuthalingam, Rajagopalan and Joel (1971); *Pomadasys jubelini* (Cuvier) by Dorairaj (1972); the mackerel, *Rastrelliger faughni* Matsui by Gnanamuttu (1972); *Ichthyoscopus inermis* (Swainson) by Kuthalingam (1972); *Malacanthus hoedtii* Bleeker by Rangarajan (1972); and a new species of a gaterinid, *Gaterin ravi* by Menon and Talwar (1973), Marichamy (1970) added the sawfish, *Pristis zijsron* Bleeker to the ichthyofauna of the Andaman Islands; Mathur and Yazdani (1970) extended the range of eel, *Pisoodonophis canerivorus* (Richardson) to the Gujarat coast; and Talwar (1971e) restricted the geographical distribution of *Gaterin chubbi* (Regan) to the western Indian Ocean and concluded that Day's (nec Cuvier) *Diagramma griseum* is conspecific with *Gaterin schotaf* (Forsskal).

The preparation of a catalogue of the fishes figured in Francis Day's *Fishes of India* in the repository of the Zoological Survey of India, Calcutta, was initiated by Talwar and Chakrapany (1970) who listed the fishes belonging to the orders Pleuronectiformes, Tetradontiformes, Lophiiformes, Batrachoidiformes and Beloniformes.

Talwar (1971f) has moved the International Commission on Zoological nomenclature to use its plenary powers to set aside all type-species selections for the genus *Chanda* Hamilton, 1822, made prior to this ruling, and having done so, to designate the species *Chanda nama* Hamilton, 1822, to be the type-species of the genus, and to place the generic name *Hamiltonia* Swainson, 1839, in the official Index of Rejected Generic Names in Zoology. This application has received strong criticism from Collette (1973) on behalf of an adhoc Nomenclature Committee of the American Society of Ichthyologists and Herpetologists, evidently based on a misunderstanding of Swainson's intentions when he proposed the genus *Hamiltonia*.

(2) FRESHWATER FISHES

Mahajan and Venkateswarlu (1971) briefly reviewed the recent trends in the taxonomy of freshwater fishes of India. Menon (1973) in an excellent paper traced the origin of the freshwater fishes of India and concluded that the evidence of the distribution of the freshwater fishes of India clearly indicates the South-Chinese origin and the subsequent spread westwards along the Himalayas during the Pliocene and south-westwards to the Peninsula during the Pleistocene.

The systematic of siluroid fishes of India continued to receive considerable attention. Jayaram (1970-1973) continued the valuable series initiated by the late Dr. S. L. Hora, entitled "Siluroid fishes of India, Burma and Ceylon", and his series "Contributions to the Bagrid fishes of India". Jayaram (1970) resurrected the specific name, *Plotosus lineatus* Thunberg, 1791, from the synonymy of *P. anguillaris* (Bloch, 1794) on nomenclatural grounds. Tilak (1972b) also dealt with the taxonomy of the genus *Plotosus* Lacepede and arrived at conclusions published earlier by Jayaram and Majumder (1967, *Proc. zool. Soc. Calcutta 20*: 137-146) evidently overlooking this important contribution. Jayaram (1971a) who studied the various genera of the family Bagridae on a world-wide basis, adduced morphological and osteological evidences to substantiate his earlier contention that the genus *Rita* Bleeker, 1858, is in need of a separate family rank. Jayaram (1971b) also adduced osteological evidences to justify his earlier proposal to split the genus *Mystus* Scopoli, 1793, into the subgenera namely *Mystus* and *Osteobagrus* Jayaram, 1955. Later, Jayaram (1973a) based on further studies, suggested the name *Aorichthys* Wu, 1939, in place of *Osteobagrus* as a distinct genus akin but apart from *Mystus* Scopoli. Tilak (1970b) described two new sisorids, *Glyptothorax garhwali* and *G. brevipinis alaknandi* from the Kumoan hills (Uttar Pradesh) and later (Tilak, 1970c) another new sisorid, *Gagata sexualis* from Daltonganj (Bihar). Ganguly, Dutta and Sen (1972) added another two new sisorids *Glyptothorax nelsoni* and *G. coheni* from Ranchi (Bihar) to the freshwater ichthyofauna of India. Jayaram (1971c) discussed the taxonomic status and the generic relationship of the rare bagrids, *Pimelodus rama* Hamilton, 182 , and *P. chandramara* Hamilton, 1822; he assigned them to the genus *Rama* Bleeker, 1858, and reconstructed their descriptions. The subsequent discovery of *Pimelodus chandramara* Hamilton from its type-locality by Jayaram (1972a) confirms his earlier contention of the validity of this bagrid. Later, Jayaram (1973b) established a new genus, *Chandramara* for accommodating this rare bagrid. Tilak (1971b) described and compared the osteocranium, the Weberian apparatus and the girdles of *Chaca chaca* (Hamilton) with those of related siluroid fishes and emphaised the important features in the osteology which characterize the family Chacidae, and concluded that the fishes of the family lie midway between the primitive and advanced siluroids. Jayaram (1972b) resurrected the sisorid fish genus *Nangra* Day, 1877, from the synonymy of *Gagata* Bleeker and discussed its affinities. Pillai and Yazdani (1972) recorded the rare Burmese catfish, *Olyra horae* (Prashad and Mukerji, 1929) from the Garo hills (Meghalaya) thereby bestowing an Indo-Burmese distribution to the species. Tilak and Hussain (1973) studied the glyptothoracoid fishes from the Doon Valley (Uttar Pradesh) and reported five new distributional records, namely *Glyptothorax cavia* (Hamilton), *G. gracilis* (Günther), *G. brevipinis brevipinis* Hora, *G. horai* Shaw and Shebbeare, and *Pseudechensis sulcatus* (McClellend). Jayaram (1973c) resurrected the genus *Laguvia* Hora, 1921, from the synonymy of *Glyptothorax* and discussed its affinity to *Hara* and the probable phylogeny of thes fishes.

Of the various taxonomic contributions on the Cyprinid fishes, Menon's (1971b) revision of the genus *Schizothorax* Heckel, 1838. deserves special mention. Menon (op. cit.) besiees describing a new taxa, *S. kumaonsis* from the Kumaon Himalayas (Uttar Pradesh), concluded that the two nominal species of this genus from India viz., *S. plagiostomus* Heckel, 1838, and *S. molesworthi* Chaudhuri, 1913, are conspecific with *S. richadsoni* (Gray, 1832). Dutt and Murthy (1971) relegated *Cirrhinus chaudhryi* Srivastava, 1968, to the synonymy of *Cirrhinus mrigala* (Hamilton, 1822). Visweswara-Rao (1971) evaluated the presence of the preorbital spine as a taxonomic character in the three species of *Danio* occurring in the environs of Jabalpur. Visweswara-Rao and Sharma (1972) described a new subspecies, *Esomus danricus jabalpurensis* from Jabalpur (Madhya Pradesh).

Of ichthyological interest is the discovery by Yazdani (1972) of a remarkable genus of fishes, *Pillaia*, represented by *P. indica*, from shillong (Meghalaya), the structural features of which are so different from other members of the order Mastocembelliformes that a new family may have to be established for its reception.

The fishes belonging to the family Ophiocephalidae is an important group of freshwater fishes and their systematics was studied by Yazdani (1971), and Yazadani and Chanda (1972). Yazdani (op. cit.) considered the assignment of *Channa marulius* (Hamilton, 1822) and *Channa striatus* (Bloch, 1793) to the genus *Channa* Gronov, 1763, as rather inappropriate in view of several osteological differences within the order Channiformes. Yazdani and Chanda (op. cit.) clarified the specific status of *Channa stewartii* (Playfair) and discussed its relationship with its congener, *Channa orientalis* (Bloch and Schneider).

Although not dealing with India, the noteworthy contribution on the taxonomy of the Burmese fish, *Indostomus paradoxus* Prashad and Mukerji, 1929, by Banister (1970) deserves mention since this fish was originally discovered by the Zoological Survey of India Expedition of 1926 in Lake Indawgyi (Upper Burma). Banister (op. cit.) proposed a new order, Indostomiformes for the reception of the family Indostomidae.

As a result of the study of the various ichthyological collections from different regions of India, substantial progress in our knowledge of the freshwater fish fauna has been achieved. Datta and Mujumdar (1970) described 75 species belonging to 33 genera and 14 families, including a new taxa, *Labeo rajasthanicus,* from Rajasthan. This was followed by several additions from Jodhpur to the Rajasthan fauna by Mathur and Yazdani (1973). Pant (1970) collected 30 species from the Kumaon hills (Uttar Pradesh); Srivastava, Chandra and Wishard (1970) listed 58 species, belonging to 36 genera, based on a small collection from the river Ken in Banda district (Uttar Pradesh); Thind and Tandon (1970) listed 33 species, belonging to 23 genera, from Sangrur district (Punjab); Rooj (1971) discussed the ichthyofauna of Bihar State; Tilak (1971a) described the fishes of the river Tawi and its tributaries (Jummu State) and later (Tilak. 1972) the fishes of Sikkim. Tilak (1973a, b) listed the freshwater and estuarine fishes of Goa and described two new taxa, *Acanthophthalmus goaensis* and *Puntius melanampyx pradhani* from this region. Menon, Rama-Rao and Sen (1972) listed the fishes of the Pulta stretch of the Hooghly river and surmised that the present picture of the ichthyofauna is likely to change as soon as the Farakka Barrage on the river Ganges is commissioned. Besides the various new tata of freshwater fishes already mentioned, Mathur and Yazdani (1971) described a new loach, *Noemacheilus rajasthanicus* from Rajasthan. Notes on extension of distribution are of the little known cyprinid, *Puntitns carletoni* Fowler to Hoshangabad (Madhya Pradesh) by Tilak (1970a); the cyprinodont, *Horaichthys setnai* Kulkarni to Narmada and Tapti rivers by Karamchandani and Pandit (1971); *Glyptothorax horai* Shaw and Shebbeare, and *Batasio tengana* (Hamilton) to the Punjab by Tilak and Tandon (1970); and *Noemacheilus denisonii* Day to Junagadh (Gujarat) by Bhargava and Mathur (1971).

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FISH ANATOMY, BREEDING ECOLOGY, WATER POLLUTION

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Introduction

The present review relates to the research work done in India in fishes during the period 1970-73. The reports from several laboratories were not available within the stipulated time and hence I am afraid many contributions have been excluded unwillingly. The amount of work done on the different aspects of fish anatomy is not very encouraging though some of the works are remarkable. In reviewing the progress of work on this subject, abstracts of contributions presented at the Indian Science Congress Sessions are not included.

1. **Histo-Physiology :** Prof. J. S. Dutta-Munshi of Bhagalpur University, Bhagalpur, and his co-workers have long been working on the various tissues in fishes. Their work has encompassed even fish endocrinology. B. N. Yadav of Gaya College, Magadh University, B. R. Singh of Bihar University, Muzaffarpur, Bihar and J. S. D. Munshi (1970) worked on the histophysiology of the Adrenocortical tissue of an air-breathing fish-*Heteropneustes fossilis* (Bloch). The morphology of the adrenocortical tissue in teleosts is highly variable. Generally, the tissue has been found to follow the higher vertebrate pattern at histochemical, physiological and biochemical level. Both interrenal and chromaffin cells have been located in the haemopoietic head kidney surrounding the cardinal vein and its branches. The gland becomes hypertrophied and adrenaline secretion enhanced during breeding period. The chrome cells failed to give positive ninhydrin and indophenol reaction.

Adrenaline injection in the fish was responsible for hypertrophy of the gland and excessive vacuolation of the internal cells while atropine treatment caused nuclear hypertrophy, cellular vacuolization and infiltration of RBC into internal area. Under fasting, vitamin C content was reduced considerably and the heat death was responsible for the hyperactivity of the gland. Taking into consideration, the impact of air-breathing habit on the physiology of the gland, the normal histochemistry of the adrenocortical tissue has been taken into consideration and compared with the water-breathing teleosts.

Another histophysiological work on the mucous cells of the respiratory epithelieum in the air-sac of an air-breathing siluroid fish—*Saccobranchus fossilis* (Bloch) has been done by B. R. Singh, G. Guha of M.D.D M. College, Muzaffarpur, Bihar and J.S.D. Munshi (1972). The injection of medullary hormones in the fish caused the mucous secretion to be increased first but decreased after subsequent treatments. Sulphated mucopolysaccharide content decreased but there has been rise in RNA matter and appearence of tongue like protrusion in the cells. With atropine treatment, there is stimulation of secretion before the inhibitory effect occurred. The number of mucous cells per cm^2 has been shown to increase or decrease with these treatments. The effect of prolonged fasting was responsible for insignificant number of mucous cells in the respiratory epithelium, decline in their secretion and disruption of the cells followed by their extrusion into the lumen of the air sac.

Singh, Guha and Munshi (1973) also published a paper on the histophysiology of the respiratory muscle of the air sac in *Saccobranchus fossilis* (Bloch). The histochemical studies of the cucullaris muscle of the air-sac of the fish show that the muscle is rich in—SH groups, phospholipid, glycogen and acid mucopolysaccharides at I bands. The muscle does not show activity of alkaline phosphatase, acid phosphatase, 5-nucleotidase except around the blood capillaries but appreciable amount of lipase and phosphatase, and very little succinic dehydrogenase (SDH) activity have been recorded. Forced physiological exercises (16 hrs) appears to cause change of metabolic pathway as evidenced from increased SDH and lipase activity followed by low phosphorylase activity.

Singh, Guha and Munshi (1973) worked on the fat depot in the air-breathing organs of some teleosts. They found large amount of reserve fat lying in between the vascular islets and the respiratory muscle of the air-sac. A direct correlation exists in between the vascularity of the organ and concentration of fat globules. The authors speculate that the large amount of lipid in the air breathing organs of these fishes might be helpful during prolonged air breathing conditions. The stored lipid has been found to be mobilized by the pharmacological action of adrenaline and atropine *in vivo* condition.

Singh, Guha and Munshi (1973) further worked on the mucous of the respiratory sac in an air-breathing fish-*Saccobranches fossilis*. The carbohydrate material of the mucous cells were identified as sulphated acid mucopolysaccharides which appeared to possess more functional carboxyl groups than sulphate groups. The mucous cells also contain mucoprotein, sialomucin, RNA, tyrosine, histidine, arginine and terminal-NH_2 groups but thiol groups and tryptophan residues were not detected histochemically. The sulphated acid mucopolysaccharide component of the secreted mucous keeps the air sac moist and lubricated during gaseous exchange.

2. **Morpho-Histology :** S. K. Moitra and his associates in the Burdwan University, Burdwan, are working for the last few years on the morpho-histology of the alimentary canal with reference to food and feeding habit. Most of us who relish freshwater fish as food have strong preference for certain varieties and the latter naturally command a much higher market price than the rest. Many varieties, on the other hand, are looked down upon as poor man's food. In order to dispel many wrong notions and prejudices still prevailing an attempt is being made by S. K. Moitra and his co-workers to elucidate the food habits of some common freshwater fishes. Moitra and Sinha (1971) worked on the morpho-histology of the alimentary canal of a carp, *Chagunius chagunio* (Ham.) with reference to the nature of taste buds and mucous cells. The relative length of gut (R.L.G.) in the fish which is an omnivorous cyprinoid, is a peculiarity. Barbels are provided with a large number of taste buds and few mucous cells and are gustatory in function. Lips are highly protrusible and are provided with well developed longitudinal muscles. Taste buds are present in the lip for detection and selection of food. Broad, well developed and distinct villi are present in the bucco-pharyngeal region. A large-number of taste buds and mucous cells are also present. Undifferentiated columnar cells present in the pharyngeal region become differentiated into mucous cells. The presence of taste buds in the oesophageal region of *Chagunius chagunio* appears to be related to its peculiar mode of feeding. The intestinal bulb is provided with compact villi probably for increasing the surface area for more efficient absorption necessitated by a low R.L.G. The intestine is not as much coiled as in the other cyprinoids. An abundance of mocous cells and the strong musculature are characteristic features of the rectal region. Mucous folds are generally high, dense, thick and compact. *C. chagunio* appears to feed on coarse food particularly, with the result that copious mucus is necessary for glueing the food together for onward transmission and for protecting the soft mucous lining from mechanical injury.

3. **Comparative Anatony :** Ajit K. Sircar of Calcutta University, Calcutta and his associates are engaged on the study of comparative anatomy, functional morphology and reproductive biology of fishes. Sircar (1970) worked

on the morphology of the urinogenital system of six species of siluroid fishes belonging to five genera under the families Heteropneustidae, Clariidae, and Schilbeidae Head-kidney is conspicuous by its absence in Schilbeidae though in other families it is invariably present. It has no nephrogenous connection with the abdominal or trunk kidney. It is composed of lymphoid tissue and is without urinary tubules, hence non-exeretory in function. Abdominal kidney is basically a paired but fused organ. It is the functional kidney in these fishes. Testis vary in shape and size, as also in position relative to the kidneys. Such variations in relation to seasonal cycle have been discussed. Seminal vesicles have been found to occur in *Heteropneustes fossilis* and *Clarias batrachus*. Their morphology, histology and functions in relation to breeding biology have been discussed. The structure of the ovaries and their variatious in relation to breeding cycle have been described. In *Ailia punctata* complete fusion of the two ovaries and the presence of a single oviduct have been recorded. Morphology and histology of the urinogenital papilla have been studied and interrelationship of the urinary and genital ducts within the urinogenital papilla has been recorded in Schilbeidae.

Sircar and Har, at present Ramananda College—Bishnupur, Bankura, W.B. (1970) worked on the seminal vesicles of two gobiid fishes—*Glossogobius giuris* (Hamilton) and *Eleotriodes muralis* (Valenciennes). The functional role of the seminal vesicles in the breeding biology of these two fishes, has been demonstrated by morphological and histological studies. In *Glossogobius*, a spermduct has a single vesicle, but in *Eleotriodes*, they are two. The relationship of the vesicles to the spermduct during breeding and non-breeding periods have been particularly observed. Histologically the vesicle in *Glossogobius* is composed of tubules lined with cuboidal cells, but in *Eleotriodes*, only the posterior vesicle has them so, while the anterior one is devoid of tubules and has a large spacious lumen lined with tall, columnar cells. The outer wall of the seminal vesicles in both the species is composed of layers of fibrous connective tissue. The functional role of the secreted products of the vesicles is interesting. Except with the fluid of the anterior vesicle of *Eleobriodes*, in both the species when testes-squash and seminal vesicular fluid are mixed, the sperms clump together forming a sperm-packet. Storge function of sperms can be assigned only to the anterior pair of vesicles in *Eleotriodes muralis*.

4. **Breeding Ecology**: Investigations on the breeding ecology of common food fishes are rather meagre. Though late, some workers are doing very extensive work in this field of fish biology.

V. Gopalakrishnan and A. Ghosh of C.I.F.R.I., Barrackpore, W.B. (1971) made observations on the abundance of *Hilsa ilisha* in the Hooghly estuary during 1971 monsoon season. Details regarding an unusual abundance have been described. Biological studies indicated that the hilsa collected were homogenous to those studied during the monsoon season of 1955. The principal factors contributing to the abundance of hilsa were found to be the occurrence of essential directive factors in the lower zone favouring large-scale spawning migration of the fish.

V. Gopalakrishnan (1971) worked on the biology of the Hooghly-Matlah estuarine system (West Bengal) (India) with special reference to its fisheries. The Hooghly-Matlah estuarine system, the major portion of which is characterised as a positive mixohaline estuary, is divided into five zones, each presenting different physico-chemical and biological conditions. The more important parameters which contribute to biological zonation in this estuarine system are temperature, salinity, turbidity and freshwater drainage. As regards the flora and fauna of the estuary, most of the data so far gathered are on the plankton and biology of commercially important fishes, salient features of which are presented and discussed. The biological characteristics of (i) the marine fishes which use the estuary as nursery ground, (ii) the species which migrate into the mouth of the estuary to form important local fisheries, and (iii) freshwater fishes which come into the estuary, are discussed. Prominent features of the fisheries potential of the estuarine system have also been given.

Ajit K. Sircar of Calcutta University and S P. Har. of Ramananda College, Bishnupur, W. B. (1973) made an extensive investigation on the ecology of an estuarine breeding ground of some gobioid fishes in West Bengal, India. A study of the breeding ecology of such gobioid fishes as *Acentrogobius .cyanomos* (Bleeker), *Scartelaos viridis* (Hamilton), *Boleophthalmus boddartic* (Pallas), *Periophthalmus schlosseri* (Pallas) and *Periophthalmus koelreuleri* (Pallas), has been made in the Ganga estuary at Alampur, Midnapore district, West Bengal, from September 1969 to September 1970. The study comprises mainly of such hydrobiological factors as temperature, rainfall, turbidity p^{H} value, dissolved oxygen, dissolved carbon dioxide and plankton. Such physico-chemical conditions as decreased salinity, increased turbidity, decreased p^{H}, optimum air and surface temperature with temporary or permanent thermocline, fluctuating D/o_2, abundance of plankton, etc. so conducive of breeding purposes, are actually brought about by the southwest monsoon. It would appear that apart from biological factors, physicochemical ones also influence the spawning of the gobioid fishes.

5. **Water Pollution**: Pollution is a recent cry in underdeveloped and developing countries. But in advanced countries like America, Japan, West Germany, Norway, Sweden, England, France, etc, for the last two decades much work has been done on this problem, and various safeguards are being taken to control industrial pollution. Inspite of our recent interest in pollution, we still know very little about the effects of the pollution hazards on fish anatomy in particular.

Dr. V. Gopalakrishnan and his associates in C.I.F.R.I., Barrackpore, W. Bengal are engaged in certain aspects of the problem of pollution. V. Gopalkrishnan, P. Roy and B. B. Ghosh (1970) dealt on estuarine pollution with special reference to Hooghly estuary. The physico-chemical and biological characteristics in an estuarine system which is influenced by strong tidal currents are so complex that a proper appreciation of the pollution problem in the same is rather difficult. Generally the the estuarine water receives all wastes discharged into the tributaries of the concerned river system as well as the effluents from surrounding areas and the effects of the tidal currents complicate the situation. Detailed investigations on the industrial pollution of the Hooghly estuary have been undertaken by the central Inland Fisheries Research Institute, Barrackpore and salient features of the data collected are given. Necessary steps to be taken for the abatement of pollution in estuaries are also indicated.

V. Gopalakrishnan (1972) worked on the biological processes involved in pollution of coastal aquaculture waters. An analysis of the basic biological processes involved in the pollution of coastal zone waters and the direct and indirect effects of pollution on primary production, metabolism, growth and reproduction are discussed in the context of coastal aquaculture.

V. Gopalakrishnan, P. Ray and B. B. Ghosh (1973) advanced further ideas on the present status of pollution in the Hooghly estuary with special reference to the adverse effects observed on the fishery resources. The paper presents latest informations regarding the domestic and municipal wastes discharged into 92 km. stretch of the Hooghly estuary and their effects on the aquatic biomass. Details on the hydrobiological conditions at the region of outfall and characters of the effluents from the more important industries are discussed in relation to the adverse effects produced on the fishery resources of the estuarine waters.

Dr. S. K. Konar of the University of Kalyani, W.B. is long engaged in the experimental use of various organophosphorous chemicals in fishery management for eradication of predaceous fishes or aquatic-insects or other predators. One of the major problems of fishery mangement is the existence of predatory insects and predatory or undesirable fishes in fishery reservoirs. The task of their removal or eradication without damage to the crops being reared is faced with many difficulties. S. K. Konar (1970) worked on the toxicity of heptachlor to aquatic life. The chlorinated hydrocarbon insecticide heptachlor is highly toxic to aquatic life. Pollution of fishery reservoirs by this insecticide as run off from treated lands will damage or destroy sport and commercial fisheries if the insecticide is not used judiciously. The problem may be solved if the highest and lowest concentrations of the insecticide are known that would kill none and all, respectively, of the important aquatic insects, effects of the insecticide on plankton, and its residual toxicity to fish in stagnant water. Again Konar (1970) reported on some effects of sublethal levels of heptachlor on Rohu, *Labeo rohita* (Hamilton). The laboratory determined so-called sublethal levels of heptachlor may result in long term effects on fish in the field conditions.

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TAXONOMY, ECOLOGY AND DISTRIBUTION OF INDIAN AMPHIBIA AND REPTILIA

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Agarwal (1971) gave systematic account of Ophidio. Collection from a 40 km. radius area of Jabalpur and its environs. Altogether thirteen species of snakes have been recorded from this area.

Ahmed (1971) has discussed the Zoogeographical distribution of Indian Ocean snakes but only the abstract of his paper has been published.

Biswas (1970) in his preliminary survey reported on the status of *Gavialis gangeticus* (Gmelin) which was carried out in 1968 in the Kosi and some of its tributaries. He has pointed out that the alarming status the species has reached in the Ganges and Kosi within last 15 or 20 years. He has also charted on the map Kosi river as the haunts of the species. Some probable causes that may be responsible for the present status of the species in these rivers have been discussed.

Biswas has also pointed out the serious status the *Crocodilus palustris* Lesson has reached in W. Bengal, Bihar and U.P. and has suggested some proposals for saving them.

Biswas, Talukdar and Chandra (1970) recorded *Python molurus bivittatus* Schlegel from Khasi Hills, Meghalaya. Though the distribution of the subspecies in the Indochinese Subregion is very well known and generally known to Ocean in the Eastern part of India, the present record by the authors in Khasi Hills, Meghalaya is importent only for its specific distribution.

Chowdhury (1970) has described a new Capitosevrid amphibian, *Porotosaurus rajareddyi*, from the Triassie yerrapalli formation of Parnhita, Godavari valley and he had given a restoration of the skull roof, general features of the skull. He thinks that the constricted Otic notch may indicate that the new Indian species is perhaps more close to Middle Triassic Capitosaurid.

Choudhury (1970) has also described two new dicynodonts from the Triassic Yerrapalli formation. The firist *Rechnisaurus cristarhynchus*, is a

Staklechcriid and the first of its kind to be reported from the Asia. Phis species shows considerable similarities to *Dianodontosaurus* of the Middle Triassic of Brazil and Argentina. The second dicynodont, *Wadiasaurus indicus* is the first Kannemey necriid to be described from India and its nearest relative is thought to be *Sangusarus* of the Middle Triassic of Zambia.

Ghose (1972) has listed all the known amphibian fossil from India together with some unidentified materials as reported in the literature and under bibliography he has mentioned 60 references mainly dealing with Indian fossil Amphibian.

Isoac (1970) has observed in a female *Rana cyanophlyctis* obtained in July 1962 at Kayna Nagar, Satara Dist. to have fully developed vocal sacs on both sides of the chin.

Krishnan (1971) recorded *Crocodilus prosus* Schneider at Vhitarkanika, on island in Bay of Bengal, off Chandbali Coast in Orissa and he thinks the place distinct in flora, fauna and terrin from the mangrove forests of Sunderbans.

Liviton and Anderson's (1970) work on Afganisthan amphibian will be useful for a study of comparative distribution in relation to Indian species.

Mansukhani and Murthy (1970) in their paper deals with the Amphibia of Rajasthan based on several collections of Zoological Survey of India. Altogether eight belonging to three species and three genera have been identified. *Rana hexadactylus* Lesson and *R. breviceps* Schneides are new record from Rajasthan.

Murthy (1971) has recorded *Cerbrus rhynchop* (Schneider) abundant at the Madras Coast and in estuaries around the city.

Murthy and Rao (1972) gave information about distribution, recognition and diagnosis of two edible frogs, *Rana tigrina* Daudin and *Rana hexadactlylus* Lesson.

Murthy (1973) suggested *Rana cynophlyctis* Schneider as the alternative specimen for laboratory studies and mentioned about its diagnostic characters and distribution of the same.

Pillai and Chandra (1973) described a new species of frog, *Philautus shillongensis* from Maghalaya and compared it with allied species including *P. cherrapunjiee* (Roonwal and Kripalani, 1961). The species differs from all other species of the genus in the absence of wabs on toes.

Pillai and Talukdar (1973) records the *Gekko gecko* (Linnaeus) from Assam which extends its known distribution in the Northeastern part of India. They tried to explain the insular distribution and in West Bengal of this species as accidental or due to human agency. But the regions mentioned in their paper fit well with the Indochinese and Malayasian Zoogeographical distribution.

Pimento (1972) recorded *Laticauda colubrina* (Schneider) from the South Sentinel Island of the Andaman group and collected some at a distance from the shore.

Prokash (1971) records *Testudo elegans* at Bisalpur, on the Western side of Aravallis. This species was known to occur from the eastern side of the Aravallis.

Sarma (1971) has studied the reptile fauna of Nagarjunsagar Project area of Guntur and Nalagonda Dist., Andhra Pradesh. In this collection there are 34 species belonging to 24 genera of 11 families—two species of Order Testudines and 32 of Squamata (16 of Suborders Sauria-4 Gekkonidae, 4 Agamidae, 4 Seincidae, 3 Lacertidae and 1 Varanidae) and 16 of Suborder Serpentes. He described two species of Scincidae based on this material of this collection.

Sarma (1970) also described a new species of scink out of the reptile collection of Western Regional Station, Poona of Z.S.I. *Eumecs poonoensis* which closely resembles *E. teniolatus* Blyth from Pakisthan.

Stwart and Daniel (1972) examined the surface structure of scales of *Gekko gecko* (linnaeus) with the scanning Electron Microscope. Though the work was carried out outside India it is concerning a species also occurring in India. Such work on other species will be of systematic value.

Tiwari and Sharma (1971) have studied the reptile collection of Western Maharashtra. The collection contain a total of 42 species belong to 24 genera of 11 families. They have recorded nine species of lizard and four species of snakes new from the area.

Tandon (1971) reports the first occurrence of mammalian and reptilian fossil remains from the Middle Eoscene (Leutelian) formation of Western India.

He gives the biostratigraphic Sequence as : First *Corbula subexarata* zone which is overlain by 4.5m. thick reptilian zone, rich in reptilian remains and contains highly gypsified skulls of *Crocodilus kutechensisn* sp., Crocodilus (?) sp. and number of vertebrae. The 3rd zone is *Nummulitus acutus*.

Venkateswarl u, Nath and Sanyal (1972) record one *gavialis gangeticus* (Gmelin) at the Badar Ghat near Patna at the confluence of Gandak with the ganges.

Yazdani and Chandra (1971) described a new toad *Ansonia meghalayana* collected from Mawblong near Cherrapunjee. It is allied to *Ansonia ornata* Gunther which occur in the Brahmagiri Hills in Coorg but differs from it in having bony ridges on the head and also lacking tympanum.

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TAXONOMY AND ZOOGEOGRAPHY OF BIRDS

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During the period under review (1970-1973), valuable contribution was made by Ali and Ripley (1970-1973) by bringing out seven volumes of the series entitled "The Handbook of the birds of India and Pakistan". The multi-volume treatise is an outcome of comprehensive avifaunal studies made by the authors as well as other ornithologists since the inception of ornithology in India. The series is expected to replace, at least in part, Stuart Baker's volumes on birds, in the Fauna of British India series (1922-1930). The Handbook Volume 4 to 9 deal with 1227 species and subspecies from Frogmonths to Pitta (Volume 4), Larks to Grey Hypocolius (Volume 5), Cuckoo-shrikes to Babaxes (Volume 6), Laughing Thrushes to Mangrove Whistler (Volume 7), Warblers to Redstarts (Volume 8) and Robins to Wagtails (Volume 9). A revised edition of the guide book to the birds of Ceylon of Henry (1971) appeared with all freshness after 16 years of its first publication. An appendix, containing additions and amendments to ranges of species, up to dating of names of many birds, has been added.

Abdulali (1970, 1972) published a series of catalogues of the birds in the collection of the Bombay Natural History Society which has been accumulating and growing in the society for the last 75 years or so. These collections have contributed to the writing of the avifauna of not only India but also of adjoining countries. Catalogues of these birds appearing in parts systematically deal with the species of orders Charadriiformes, Columbiformes, Psittaciformes, Cuculiformes, Strigiformes, Caprimulgiformes, Apodiformes, Trogoniformes and the family Alcedinidae of the Order Coraciiformes. Information and taxonomic details catered about species, subspecies, and comments on variations and zoogeographic distribution, etc., are of great value to the students of ornithology.

Recent avifaunal explorations conducted in various regions of India and bird observations made by professional and amateur ornithologists have brought out interesting results. Abdulali (1970) recorded the migratory Jungle Nightjar, (*Caprimulgus indicus jotaka*), a migrant from Japan and China in the Andamans. Abdulali (1970) also reported on the occurrences of the Great Snipe (*Capella* *media)* in Burma and India. Abdulali and Hussain (1971) obtained the same bird for the second time in the Andamans. This implies that it is a regular visitor to Indian region. Abdulali (1971) recorded same 78 species of birds from the Narcondam and South Andaman Islands. Abdulali and Hussain (1971) discovered the southern-most breeding area of the Sykes' Nightjar (*Caprimulgus mahrattensis*) in Gujarat which was supposed to be the wintering ground of the bird. These authors (1971) also recorded the Eastern Ringed Plover (*Charadrius hiaticula tundrae*) in Tamil Nadu. They (1972) discovered the Eastern Palm Swift (*Cypisurus parvus infumatus*) from north of Brahmaputra, Assam. Das (1971) established two new records, namely, the Indian Purple Moorhen (*Porphyrio porphyrio poliocephalus*) and the Pied Cuckoo-Shrike (*Lalage migra*) from the Andaman and Nicobar Islands. Desfayes (1971) recorded the Tibetan Twite (*Acanthis flavirostris*) occuring in Nepal for the first time. Dharmakumarsinhji (1972) noted the extention of the breeding range of the Black-shafted Little Tern (*Sterna albifrons saundersoni*) in Okhamandal peninsula, Gujarat, so far not known in the Indian territory. Galushin (1971) recorded a huge urban population of birds of prey in Delhi comprised of six species, of which the Pariah kite, *Milvus migrans*, consists of 83 percent of the population. Gauntlett (1971) listed 106 species of birds from Durgapur Barrage which has been found to be a good wetland waterbird habitat. Gauntlett (1972) also made some observations on birds of Kashmir and furnished a systematic list of 111 species of hill birds which he compared with the data given in "The breeding birds of Kashmir" by Bates and Lowther in 1952. Jackson (1971) supplied random notes on 58 species of birds of Kerala, which were based on observations made by him in Vandiperiyar-Peermade area of Kerala, These contribute additional information to the comprehensive report of Salim Ali's "Birds of Kerala" published in 1969. Ketkar and Grey Lincoln (1971) reported on the occurrence of the flamingo *Phoenicopterus ruber*) in the interior of Maharashtra about 112 kilometres from Arabian Sea. Khachar (1971) recorded for the second time the Barheaded Goose (*Anser indicus*) in Jasdon, Gujarat. Krishnaraju and Selvin (1971) recorded for the first time the little Spider Hunter (*Arachnothera longirostris*) in the Eastern Ghats and added northern Andhra to its range. Krishnaraju and Sekhar (1971) reported on some six interesting birds collected from pt.Calimere which have not hitherto been recorded from Tamil Nadu. Krishnaraju, Sekhar and Selvin (1972) recorded some movements of Blyth's Reed Warbler (*Acrocephalus dumetorum*) through pt. Calimere. It seems that due to inclement weather prevailing then, these birds were driven to pt. Calimere while travelling southward to Ceylon. Nedon (1972) recorded Houbara Bustard (*Chlamydotis undulata*) in Kashmir. Nepali and Fleming (1971) recorded nine species, namely. *Botaurus stellaris*, *Amaurornis* *fuscus*, *Streptopelia senegalensis*, *Lanius excubitor*, *Sturnus pagodarum*, *Acrocephalus stentoreus* *Lonchura malacca*, *Emberiza melanocephala* and *E. spondecephala* for the first time in Nepal. Saha, George, Ghosal, Mookerjee, Poddar, Ghosh, Das, Gogate and Biswas (1971) noted some interesting birds from the Salt Lakes near Calcutta, one of which was the Indian Great Reed Warbler (*Acrocephalus stentoreus*) which has hitherto been known only as a wintering bird in Bengal, has been found to be resident there.

Taxonomical notes of interest have been published on different groups of birds. Abdulali (1971) recommended resuscitation of *Otus bakkamoena stewarti* Koelz which was synonymized with *gangeticus* by Ali and Ripley in the Handbook of the birds of India and Pakistan Volume 3. Abdulali and Grubh (1970) described a new subspecies of the Blackcrested Baza (*Aviceda leuphotes*) from the Andaman Islands. Amadon (1970) gave a useful summary from a zoological point of view of the taxonomic categories below the level of genus. Harrison and Harrison (1972) reported on the occurrence of Pagets Pochard for the first time from India, the hybrid being a typical intermediate type between the two parent species, *Aytha ferina* and *Aytha nyroca*. Kahl (1972) suggested that all Wood-Storks be combined in the genus *Mycteria* which includes the Indian species also. Thomson (1972, not listed), commented on Kahl's suggestion of the generic name *Mycteria* for Wood-Storks and supported the merging of the genus *Mycteria* and *Ibis*. Mukherjee (1970) suggested that *Pachycephala grisola* should be accepted as the correct name for the Mangrove Whistler so as to avoid taxonomic confusion. Mukherjee and Dasgupta (1973) discussed the taxonomic status of the genus *Sauropatis* (family Alcedinidae) and gave ample justification to separate it from the genus *Halcyon* with which it was synonymised. Wells (1972) proposed two amendments to the "Handbook of the birds of Pakistan" concerning the status of *Cuculus saturatus* and *C. poliocephalus*.

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REVIEW OF THE SCIENTIFIC WORK PUBLISHED FROM 1971—1973 ON THE TAXONOMY, ECOLOGY AND DISTRIBUTION OF INDIAN MAMMALS

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Abe (1971) gave a taxonomic and ecological account of 31 species of small mammals from Central Nepal. The Composition of the fauna of this region has also been compared with that of Japan.

Agrawal (1971) tried to correlate ecology with the morphological structure of gerbils (Family Muride, subfamily Gerbillinae). The adaptation is mainly due to fossorial and saltatorial habits and is reflected in the limbs and the tympanic bullae of skull.

While giving a taxonomic account of mammals from Goa, Agrawal (1973) reported, for the first time, 22 species from that area, including one from the Indian region. He synonymized *Cynopterus sphinx gangeticus* Anderson with *Cynopterus sphinx sphinx* (Vahl) and *Pipistrellus dormeri caurinus* Thomas with *Pipistrellus dormeri dormeri* (Dobson).

Agrawal and Chakraborty (1971 and 1972) extended the range of distribution of the Lesser Bandicoot Rat, *Bandicota bengalensis kok* and the Turkestan Rat, *Rattus ratotides trukestanicus* to Uttar Pradesh, India, and recorded for the first time six species of mammals from Nepal. In addition, they described a new species of Pika, *Ochotona mitchelli,* from that country. It is characterized by its dorsal colouration being slaty, grizzled with white and Raw Umber, head and snout Saffron-Yellow and by the presence of a Pinkish-Buff spot behind ears.

Agrawal and Sinha (1973) studied the structure of bacula of three genera and six species of Megachiroptera and 14 genera and 27 species of Microchiroptera from the Oriental region. They reached the conclusion that remarkable differences exist in the bacula up to the generic level. The inter-specific differences are generally in the size and minor details of shape. The role played by them in defining relationships in bats appears to be limited.

Berwick and Jerdon (1971) conducted a census of six species of ungulates, namely *Sus scrofa*, *Gazella gazella bennetti*, *Tetraceros guadricornis*, *Boselaphus tragocamelus*, *Axis axis* and *Cervus unicolor* in the Gir Forest, Gujarat, and compared their niche-relationship.

Based on a comparative study of skulls of the two living genera of rhinoceroses, namely *Rhinocercs* Linn. and *Dicerorhinus* Gloger, Chakraborty (1973) differentiated the former from the latter mainly by having united post-glenoid and post-tympanic processes, very deep fronto-parietal sulcus and the orbito-nasal length shorter than Orbitoaural length. Most of these differences may be attributed to the number of horns present.

Chakraborty and Ghosal (1971) came across a skull of the gerbil, *Tatera indica* Hardwicke from Punjab, having an anomalous growth of lower incisors.

Chaturvedi (1973) gave an ecological account of the fauna especially of the mammals, of Nagarjuna Sagar area, Andhra Pradesh, before the completion of this Dam project.

Das and Sinha (1972) studied some aspects of taxonomy and breeding biology of the Short-nosed Fruit Bat, *Cynopterus sphinx* (Vahl) in eastern India. The ranges of the lengths of ear and forearm have been found to be greater than already recorded. The bat is polyoestrous and breeds throughout the year.

Das and Agrawal (1973) extended the range of distribution of 22 species of mammals to Orissa.

Davidar (1971*a*) conducted census of the Nilgiri Tahr, *Hemitragus hylocrius* on the Grass Hills in the Anamallais, Tamil Nadu. The total number is estimated to be around 138. The same author (1971*b*), based on an earlier report by Williams (1970) that ash-coloured gaur (*Bos gaurus*) occurs in the Manjampatti Valley, Coimbtore, Tamil Nadu, visited the place in 1970 and returned without any positive result.

Ghose (1971) recorded some of the habits and habitat of the Pachmarhi Hare, *Lepus nigricollis mahadeva* wroughton and Ryley, that he observed in the field in Madhya Pradesh, during winter months.

Ghose and Chaturvedi (1972) extended the range of distribution of *Herpestes palustris* Ghosh from Salt Lakes, Calcutta, to Bhasna, Diamond Harbour, 24 Parganas, West Bengal. A few strongylid nematodes, hithertofore unrecorded, were found in its rectum.

Ghose and Guha Roy (1973) studied the intraspecific variability of a number of body and skull measurement in a population of the Sikkim Vole, *Pitymys sikimensis*, from Darjeeling District, West Bengal. The population shows significant sexual dimorphism in the mean lengths of the head and body and occipito-nasal.

Hill (1971) is of the opinion that *Pteropus tytleri* from Andaman Islands and *Pteropus satyrus* from Narcondam Island are subspecies of *Pteropus melanotus*. Parallelism in colour variation is demonstrated between *Pteropus melanotus* from the Andaman and Nicobar Islands, and *Pteropus geminorum* from the islands of Mergui Archipelago.

Khajuria (1973) recorded the genera *Crocidura* and *Talpa* from Madhya Pradesh, based on the faecal pellets of an owl and on Visual observation respectively.

Krishnan (1972 and 1973) dealt with the status, distribution, size, colour variations and habits of 33 species of mammals (5 species of Primates, 13 species of Carnivora, 1 species of Lagomorpha, 3 species of Rodentia, 10 species of Artiodactyla and 1 species of proboscidea) in peninsular India.

Mallinson (1971*a* and *b*) reported the occurrence of two rare species of mammals, namely the Hispid Hare (*Caprolagus hispidus*) and the Pygmy Hog (*Sus salvanius*), at Rajgarh Forest Reserve, and Attareekhat and Paneery Tea Estates respectively, in the Mangaldai Subdivision of Darrang District, Assam.

Martens and Nielhammer (1972) made a detailed taxonomic study of two species of field mice namely *Apodemus sylvaticus wardi* and *Apodemus gurkha* from Nepal. They conclude that *Apodemus gurkha* belong to the eastern species group of *Apodemus* namely subgenus *Alsomys*, and that it should enjoy specific rank instead of being treated as subspecies of *Apodemus flavicollis* as has been heretofore done.

Mandal (1973) studied the structure of the appendicular skeleton of four species of the genus *Panthera* namely *P. pardus*, *P. tigris*, *P. leo* and *P. uncia*, to bring forth the salient features of differentiation and tried to correlate them with their habits.

Misra (1973) made a census of wild life at Palamau National Park, Bihar, by Track Count method. He estimated the population of different species of mammals as : Tiger 2, Elephant 24, Gaur 73, Sambar 160, Blue Bull 20, Chital 623, Barking Deer 94, Wild Boar 349 and Sloth Bear 2.

Prakash (1972 and 1973) and Prakash *et al.* (1971*a*) studied the body-size, sex-ratio, ecological distribution and the relative number in relation to ecological factors of the Indian Desert Gerbil, *Meriones hurrianae* in the Rajasthan Desert. He found that male gerbils are heavier than females. The weight is minimum during summer and maximum during monsoon, when the green food is freely available. The gerbil prefers the sandy habitat more than gravelly or ruderal, It is more commonly found in grasslands having *Aristida* sp. as the chief component. Amongst cultivated fields, the frequency of its occurrence is highest in cotton, wheat and Bajra fields. The population of this gerbil is related to soil characteristics and grass cover, being less in clayey and compact soils and those covered with grass. It is maximum during winter and spring due to high rate of breeding during and after the monsoon. Prakash et al (1971*b*) made an ecological evaluation of the rodent populations in the desert biome of Rajasthan.

Prakash *et al.* (1971*c*) recorded six species of rodents for the first time from Rajasthan Desert, and extended the range of distribution of another three. Prakash (1973*b*) reported the occurrence of the Anderson's Shrew, *Suncus stoliczkanus* throughout Rajasthan in addition to Ajmer recorded earlier. The population appears to be smaller than that of *Suncus stoliczkanus leucogenys* from Ajmer. Therefore, the subspecific identification is still doubtful.

Schaller (1971) studied the status, distribution and biology of the Nilgiri Tahr (*Hemitragus hylocrius*) in Southern India, during 1969. He estimated the population of Tahr around 1000, of which 300 were in Nilgiris, 530 in the High Range of Kerala and the remainder in the Annamalai and Palni Hills, Tamil Nadu.

As the name *Mus rattoides* Hodgson (1845) is preoccupied by *Mus rattoides* Picket & Picket (1844), the next available name *Rattus-turkestanicus* (Satunin, 1903) has been proposed for this species by Schlitter and Thonglongya (1971). They have recognized only three subspecies *Rattus turkestanicus turkestanicus, Rattus turkestanicus shigarus* and *Rattus turkestanicus vicerex* under it.

From a detailed study of the type specimen of *Nycticejus emarginatus* Dobson, Sinha and Chakraborty (1971) arrived at the conclusion that it is a valid species under the genus *Scotomanes* Dobson. It differs from its allied species *Scotomanes ornatus* in having the forearm and toothrow smaller.

Based on a single specimen of bat from Madura, Tamil Nadu, Thonglongya (1972) described a new genus and species of Fruit Bat viz. *Latidens salimalii* (Family Pteropidae). The genus is characterized by the presence of one pair of incisor in each jaw, four pairs of cheekteeth in upper and five pairs in lower jaw and by the absence of post-orbital foramen.

Tiwari *et al.* (1971) gave a taxonomic and ecological account of eight species of mammals from the Western Ghats. They resucitated the subspecies *Bandicota indica malabarica* from Western Ghats and elevated *Rattus rattus rufescens* to specific rank, as *Rattus rufescens*.

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